# TRANSACTIONS

OF THE

# American Fisheries Society

---

**FIFTY-EIGHTH ANNUAL MEETING**

**SEATTLE, WASHINGTON**

**AUGUST 29, 30 and 31, 1928**

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**Published Annually by the Society**

**HARTFORD, CONNECTICUT**

**1928**

# American Fisheries Society

ORGANIZED 1870 INCORPORATED 1910

## *Officers for 1928-1929

*President* ..... C. F. CULLER, LaCrosse, Wis.
*Vice-President* ..... DAVID L. BELDING, Boston, Mass.
*Secretary* ..... CARLOS AVERY, New York, N. Y.
*Treasurer* ..... CARLOS AVERY, New York, N. Y.
*Librarian* ..... JOHN W. TITCOMB, Hartford, Conn.

### Vice-Presidents of Divisions

*Fish Culture* ..... JAMES A. LAIRD, Oakdale, N. Y.
*Aquatic Biology and Physics* ..... H. S. DAVIS, Washington, D. C.
*Commercial Fishing* ..... JOHN P. BABCOCK, Victoria, B. C., Canada.
*Angling* ..... WILLIAM KEIL, Boise, Idaho.
*Protection and Legislation* ..... E. LEE LECOMPTE, Baltimore, Md.

### Executive Committee

L. H. SPRAGLE, *Chairman* ..... Cresco, Pa.
T. F. WILCOX ..... New York, N. Y.
D. E. PETTIS ..... Phoenix, Ariz.
GEORGE W. MCCULLOUGH ..... St. Paul, Minn.
J. A. MOTHERWELL ..... Vancouver, B. C., Canada.
KEITH MCCANSE ..... St. Louis, Mo.
GLEN C. LEACH ..... Washington, D. C.

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J. A. RODD ..... Ottawa, Canada.
GLEN C. LEACH ..... Washington, D. C.
F. C. WALCOTT ..... Norfolk, Conn.
C. MCLEAN FRAZIER ..... Vancouver, B. C., Canada.

### Committee on Relations with National and State Governments

WILBERT A. CLEMENS, *Chairman* ..... Nanaimo, B.C., Canada.
HENRY O'MALLEY ..... Washington, D. C.
JOHN W. TITCOMB ..... Hartford, Conn.
CHARLES R. POLLOCK ..... Seattle, Wash.
FRED A. WESTERMAN ..... Lansing, Mich.
V. K. IRION ..... New Orleans, La.

### Publications Committee

DAVID L. BELDING ..... Boston, Mass.
JOHN W. TITCOMB ..... Hartford, Conn.
GEORGE C. EMBODY ..... Ithaca, N. Y.
H. S. DAVIS ..... Washington, D. C.

*For street address see membership list.

## PRESIDENTS' TERMS OF SERVICE AND PLACES OF MEETING

The first meeting of the Society occurred December 20, 1870. The organization then effected continued until February, 1872, when the second meeting was held. Since that time there has been a meeting each year, as shown below. The respective presidents were elected at the meeting, at the place, and for a period shown opposite their names, but they presided at the subsequent meeting.

| | | | |
|---|---|---|---|
| 1. | William Clift | 1870-1872 | New York, N. Y. |
| 2. | William Clift | 1872-1873 | Albany, N. Y. |
| 3. | William Clift | 1873-1874 | New York, N. Y. |
| 4. | Robert B. Roosevelt | 1874-1875 | New York, N. Y. |
| 5. | Robert B. Roosevelt | 1875-1876 | New York, N. Y. |
| 6. | Robert B. Roosevelt | 1876-1877* | New York, N. Y. |
| 7. | Robert B. Roosevelt | 1877-1878 | New York, N. Y. |
| 8. | Robert B. Roosevelt | 1878-1879 | New York, N. Y. |
| 9. | Robert B. Roosevelt | 1879-1880 | New York, N. Y. |
| 10. | Robert B. Roosevelt | 1880-1881 | New York, N. Y. |
| 11. | Robert B. Roosevelt | 1881-1882 | New York, N. Y. |
| 12. | George Shepard Page | 1882-1883 | New York, N. Y. |
| 13. | James Benkard | 1883-1884 | New York, N. Y. |
| 14. | Theodore Lyman | 1884-1885 | Washington, D. C. |
| 15. | Marshall McDonald | 1885-1886 | Washington, D. C. |
| 16. | W. M. Hudson | 1886-1887 | Chicago, Ill. |
| 17. | William L. May | 1887-1888 | Washington, D. C. |
| 18. | John Bissell | 1888-1889 | Detroit, Mich. |
| 19. | Eugene G. Blackford | 1889-1890 | Philadelphia, Pa. |
| 20. | Eugene G. Blackford | 1890-1891 | Put-in Bay, Ohio. |
| 21. | James A. Henshall | 1891-1892 | Washington, D. C. |
| 22. | Herschel Whitaker | 1892-1893 | New York, N. Y. |
| 23. | Henry C. Ford | 1893-1894 | Chicago, Ill. |
| 24. | William L. May | 1894-1895 | Philadelphia, Pa. |
| 25. | L. D. Huntington | 1895-1896 | New York, N. Y. |
| 26. | Herschel Whitaker | 1896-1897 | New York, N. Y. |
| 27. | William L. May | 1897-1898 | Detroit, Mich. |
| 28. | George F. Peabody | 1898-1899 | Omaha, Nebr. |
| 29. | John W. Titcomb | 1899-1900 | Niagara Falls, N. Y. |
| 30. | F. B. Dickerson | 1900-1901 | Woods Hole, Mass. |
| 31. | E. E. Bryant | 1901-1902 | Milwaukee, Wis. |
| 32. | George M. Bowers | 1902-1903 | Put-in Bay, Ohio. |
| 33. | Frank N. Clark | 1903-1904 | Woods Hole, Mass. |
| 34. | Henry T. Root | 1904-1905 | Atlantic City, N. J. |
| 35. | C. D. Joslyn | 1905-1906 | White Sulphur Springs, W. Va. |
| 36. | E. A. Birge | 1906-1907 | Grand Rapids, Mich. |
| 37. | Hugh M. Smith | 1907-1908 | Erie, Pa. |
| 38. | Tarleton H. Bean | 1908-1909 | Washington, D. C. |
| 39. | Seymour Bower | 1909-1910 | Toledo, Ohio |
| 40. | William E. Meehan | 1910-1911 | New York, N. Y. |
| 41. | S. F. Fullerton | 1911-1912 | St. Louis, Mo. |
| 42. | Charles H. Townsend | 1912-1913 | Denver, Colo. |
| 43. | Henry B. Ward | 1913-1914 | Boston, Mass. |
| 44. | Daniel B. Fearing | 1914-1915 | Washington, D. C. |
| 45. | Jacob Reighard | 1915-1916 | San Francisco, Calif. |
| 46. | George W. Field | 1916-1917 | New Orleans. La. |
| 47. | Henry O'Malley | 1917-1918 | St. Paul, Minn. |
| 48. | M. L. Alexander | 1918-1919 | New York, N. Y. |

| | | | |
|---|---|---|---|
| 49. | Carlos Avery | 1919-1920 | Louisville, Ky. |
| 50. | Nathan R. Buller | 1920-1921 | Ottawa, Canada. |
| 51. | William E. Barber | 1921-1922 | Allentown, Pa. |
| 52. | Glen C. Leach | 1922-1923 | Madison, Wisconsin. |
| 53. | George C. Embody | 1923-1924 | St. Louis, Mo. |
| 54. | Eben W. Cobb | 1924-1925 | Quebec, Canada. |
| 55. | Charles O. Hayford | 1925-1926 | Denver, Colorado. |
| 56. | John W. Titcomb | 1926-1927 | Mobile, Alabama. |
| 57. | Dr. Emmeline Moore | 1927-1928 | Hartford, Conn. |
| 58. | C. F. Culler | 1928-1929 | Seattle, Washington |

*A special meeting was held at the Centennial Grounds, Philadelphia, Pennsylvania, October 6 and 7, 1876.

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# PART I

# BUSINESS SESSIONS

# PROCEEDINGS

## of the

## American Fisheries Society

## FIFTY-EIGHTH ANNUAL MEETING

## at

## SEATTLE, WASHINGTON

### August 29, 30 and 31, 1928

The Fifty-Eighth Annual Meeting of the American Fisheries Society was held at the Olympic Hotel, Seattle, Wash., August 29 to 31, 1928. The meeting on August 30 was held at the Green River Hatchery, near Auburn, Washington.

### REGISTERED ATTENDANCE

AVERY, CARLOS, New York City.
BABCOCK, JOHN P., Nanaimo, B. C.
BAKER, SHIRLEY, San Francisco.
BELL, F. HOWARD, Seattle, Wash.
BERRY, FRANK, Tacoma, Wash.
BIDDLE, J. H., Vancouver, B. C.
CAYON, H. T., Deer Harbor, Wash.
CLEMENS, WILBERT A., Nanaimo, B. C.
COBB, EBEN W., Farmington, Conn.
COBB, JOHN N., Seattle, Wash.
CULLER, C. F., LaCrosse, Wis.
DEFOREST, BYRON, Great Falls, Mont.
DUNLOP, HENRY A., Seattle, Wash.
DYMOND, J. R., Toronto, Canada.
EINARSEN, ARTHUR S., Seattle, Wash.
FASTEN, NATHAN, Oregon.
FOERSTER, R. E., Vedder Crossing, B. C.
FRAZIER, C. MCLEAN, Vancouver B. C.
FREEMAN, WILLIAM, Seattle, Wash.
GARFIELD, C. N., Seattle, Wash.
GORDON, SETH E., Chicago, Ill.
GRAY, STEDMAN H., Seattle, Wash.
GREENWICH, A. N., Seattle, Wash.
HARRISON, C. W., Vancouver, B. C.
HOONAGLE, G. W., Yes Bay, Alaska.
HUBBARD, W. F., New Hampshire.
HURLBURT, H. F., East Lynn, Mass.
IRION, V. K., New Orleans, La.
JAMES, M. C., Washington, D. C.
JONES, WESLEY L., Seattle, Wash.
JORGENSEN, ED., Sedro Woolley, Wash.
KEIL, WILLIAM M., Boise, Idaho.
KEMMERICH, JOE, Birdsview, Wash.
KINKAID, TREVOR, Seattle, Wash.
LAIRD, JAMES A., Oakdale, N. Y.
LECOMPTE, E. LEE, Baltimore, Md.
LLOYD, HOYES, Ottwa, Can.
LOCKE, S. B., Ogden, Utah.
LOOSANOFF, VICTOR, Seattle, Wash.
MADSEN, D. H., Salt Lake City, Utah.
MAYBURY, CHARLES R., Olympia, Wash.
MAYHALL, L. E., Seattle, Wash.
MCCANSE, KEITH, Jefferson City, Mo.
MCLEAN, C., Vancouver, B. C.
MILES, LEE, Little Rock, Ark.
MOORE, DR. EMMELINE, Albany, N. Y.
NIGHTENGALE, R. H., Seattle, Wash.
O'MALLEY, HENRY, Washington, D. C
PARKS, C. T., Seattle, Wash.
PEARSON, T. GILBERT, New York City.
PERRY, E. S., Santa Fe, N M.

PETERSON, C. P., Bisbee, N. D.
PETTIS, D. E., Phoenix, Arizona.
POLLOCK, CHAS. R., Seattle, Wash.
QUINN, I. T., Montgomery, Ala.
RATHBUN, S. F., Seattle, Wash.
REDINGTON, PAUL G., Washington, D. C.
ROWLEY, CLINTON, W., Seattle, Wash.
SCHEFFER, T. H., Puyallup, Wash.
SCHOFIELD, J. W., Big Timber, Mont.
SCHOFIELD, E. C., San Francisco.
SCHOFIELD, N. B., San Francisco.
SHELDON, H. P., Washington, D. C.
SMITH, A. B., Austin, Tex.
SPRAGLE, L. H., Cresco, Pa.
STUART, R.Y., Washington, D. C.
SURBER, T., St. Paul, Minn.
SYNNESTVEDT, H., Kalama, Wash.
THOMAS, R. E., Boise, Idaho.
THOMPSON, WILL H., Seattle, Wash.
THOMPSON, W. L., Orgeon.
TITCOMB, J. W., Hartford, Conn.
TREECE, I. H., Anaconda, Mont.
TRUMBO, JOHN L. Frankfort, Ky.
TUCKER, W. J., Austin, Texas.
VIOSCA, PERCY, JR., New Orleans,
VLOTSCH, JOHN C., Oregon.
WARD, GUY, Seattle, Wash.
WARD, HENRY, B., Urbana, Ill.
YORKE, R. H. Metaline Falls, Wis.
YOUNG, E. C., Ottawa, Can.
ZELLERBACH, I., San Francisco.

## BUSINESS SESSIONS

The President, Dr. Emmeline Moore of Albany, N. Y., called the meeting to order on Wednesday morning, August 29, 1928.

Greetings were extended by Mr. Charles R. Pollock of the State Fisheries Department, Seattle, Wash., Chairman of the Washington Arrangements Committee.

PRESIDENT MOORE: The Fifty-eighth Annual Meeting of the American Fisheries Society is hereby convened. When by constitutional amendment provision was made for the five vice-presidents of the divisions of Fish Culture, Aquatic Biology and Physics, Commercial Fishing, Angling, Protection and Legislation, there came into operation automatically machinery for giving information regarding all lines of activities carried on by or in connection with the American Fisheries Society. Within the last few years these reports have given so adequately the status of the Society and the trend of progress that it seems unnecessary for me now to reiterate them in a presidential address. So there remains for me merely to express to our perfect host, Mr. Pollock, the thanks and pleasure of this Society in meeting at Seattle. There remains also for me to extend a cordial welcome to the new members of the Society, not forgetting, either, a tribute to the hardy perennials, those who make annual pilgrimages to the meetings of the Society and who represent the bulwark of the organization. Nor do I wish to omit the occasional visitor—as good old Izaak Walton might say, with great felicity, "Men of mild, and sweet, and peaceful spirits, as indeed all anglers are."

## REPORT OF THE SECRETARY

*To the Officers and Members of the American Fisheries Society:*

Since the last Secretary's report was written seventy-three new members have been added to the membership roll, of which sixty are Active members; ten clubs or dealers, one Life member, one Library membership, and one State membership. During this period twenty-four members have been dropped for non-payment of dues, eight have resigned, and six have died —a total of thirty-eight, leaving a net gain of thirty-five members for the year.

Members who have been most active in promoting new memberships are ex-President John W. Titcomb; James A. Laird of the Southside Sportsmen's Club of Oakdale, Long Island; President Dr. Emmeline Moore; Capt. C. F. Culler of the United States Bureau of Fisheries; ex-President Charles O. Hayford; and Fred A. Westerman, Superintendent of Fish Propagation of Michigan.

While the gain in membership is not impressive so far as numbers is concerned, the active paid membership of the Society is larger today than it ever has been in its history.

As shown by the Treasurer's report, the Society is also in better financial condition than it ever has been, having been rescued from a condition of comparative insolvency and put upon a sound financial basis with a substantial surplus within a comparatively short time. The reasons for this improvement are several, among which are the very efficient and methodical manner in which the Treasurer has collected the dues of members, the furnishing of printed Transactions only to members not in arrears, the loyalty of a few members who have been active in securing new memberships, and a substantial saving which has been effected in the printing of the annual Transactions through special arrangement made by the Librarian, Mr. John Titcomb.

The Treasurer in his report has recommended that the offices of Secretary and Treasurer be consolidated in the interest of economy. Doubtless such purpose would be served by consolidating these two offices as it would save considerable in postage, but I wish to suggest that it should not be done unless it can be arranged so that the Publications Committee will relieve the Secretary of the work of editing, preparing for printing, and proof-reading of the annual Transactions. It might be possible to secure a Secretary equipped with sufficient competent clerical help to care for all such work, but it may not be an easy matter to find some one so equipped and who is willing to undertake all the work which would fall to him under such a combination of offices, unless the editorial work should be taken care of by a special committee.

At the meeting of the Society two years ago, the by-laws were amended to permit the President, Secretary, and Treasurer to transfer mem-

bers from the Active list to the list of Life members at their discretion for good and sufficient reason, such as inability to pay dues, provided that no member should be so transferred unless he shall have paid dues as an Active member for at least twenty-five years. Since that time only one member has been so transferred. There is, in accepting the transfer authorized in this provision, an element of humiliation, and I wish to renew the suggestion made by the Treasurer heretofore, that this provision be so modified that any Active member having paid dues for twenty-five consecutive years may at his own option on request be transferred to the list of Life members. There are on the membership list only 19 members who would now be eligible to such transfer, and it is altogether likely that very few of them would avail themselves of the privilege. In twenty-five years an Active member pays in annual dues $75. The Life membership fee is $50. It would seem an entirely fair arrangement to accord the Active paying member some recognition of his continuous loyalty during a long period of years in this manner; and it can be said with confidence that it would not result in any serious financial loss to the Society. The Active membership list includes many persons who are devoting their entire lives to the work of fish culture or some allied profession for very moderate compensation. Such a change as here suggested in our by-laws would be a gesture of recognition to our loyal Active members for their contribution to the work and purposes of the Society.

At the last annual meeting a fund was started for the purpose of compiling and publishing an analytical index or catalogue of the publications of the Society. The Treasurer reports that the sum of $180 has been so far contributed toward this fund. The work of indexing, which is in charge of the Librarian, has been begun and it will soon be necessary to have a substantial amount available if the index is to be printed. It should not be necessary to draw on the current income or the permanent fund of the Society for this purpose; and it is suggested that invitation be extended at this meeting for additional contributions to this catalogue fund. The value of a complete analytical index of the publications of the Society cannot be overestimated. Officers of the Society realize this possibly more than any one else because they are constantly in receipt of correspondence requesting information which could be obtained readily from libraries containing the Transactions of the Society, if such an index were available. Such an index will stimulate the sale of the Transactions to both libraries and individuals.

Respectfully submitted,

CARLOS AVERY, *Secretary.*

The report of the Secretary was, on motion, accepted.

In the absence of the Treasurer, Professor John N. Cobb, who was appointed Treasurer pro tem, read the report of the Treasurer.

## REPORT OF THE TREASURER

*To the American Fisheries Society*:

Herewith is submitted the annual report of the Treasurer covering the period from the last annual meeting held at Hartford, Connecticut, August 8, 1927, to July 13, 1928 inclusive.

For the second time it is a pleasure for me to report the finances of the Society for the past year. My preceding report showed that the financial standing of the Society was then in the most prosperous condition of the Society's history with assets totaling $4,000, all clear. This year our condition is even bettered to the extent of several hundred dollars greater than last year and this condition has been obtained despite the fact that we have received no funds from donations or sources other than our regulation revenue items and yet have not added materially to the membership of the Society after the usual losses have been taken into account.

The receipts from our annual dues, life memberships and the sale of publications has totaled $1,943.50, or $109.69 less than last year. This was practically due to our receiving only one life membership. The increased amount, however, from the sale of publications has counter-balanced the loss of revenue from dues from individual members and libraries. Our revenue from clubs and state memberships was practically the same as 1926 and should be increased, especially as therein lies our greatest margin of profit on furnishing the Transactions and also as the revenues from such are constant and reliable and will to a great extent counter-balance our annual loss in individual active members. Inasmuch, also, as the revenue is an uncertain factor, efforts should be always maintained and even increased to keep the active individual members enrolled in goodly numbers, as they are mainstay of the Society.

This year we spent $826.53 for the Transactions—an increase over the previous year of $112.91 but just as the sale of publications practically offset the loss of annual dues from individual active members so in like manner the reduced cost of operation of the Secretary's, Librarian's and Treasurer's offices to the extent of $246.33 has more than compensated for such an increased expenditure.

The writer submits this as his fifth and last report as he is hoping that the Society may see fit to consolidate the Treasurer's office with that of the Secretary, a procedure employed in many scientific societies. Such a change in our organization would result in decreased cost of

operation for the Society, a time saver and a more efficient administration of the Society's business. It would also allow the writer to retire from active office-holding as he greatly desires.

Your attention may now be invited to the following items:

## GENERAL FUND

### *Receipts*

| | | |
|---|---|---|
| Balance on hand at meeting of 1927 | | $193.67 |
| Annual Dues | | |
| Individuals and Libraries | | |
| For the year 1924 | $3.00 | |
| For the year 1925 | 12.00 | |
| For the year 1926 | 45.00 | |
| For the year 1927 | 1,269.32 | |
| For the year 1928 | 35.00 | |
| Clubs and Dealers | | |
| For the year 1927 | 160.00 | |
| For the year 1928 | 5.00 | |
| State Memberships | | |
| For the year 1926 | 10.00 | |
| For the year 1927 | 170.00 | |
| Life Membership | 50.00 | |
| Sale of Publications | 184.18 | |
| Catalog Fund | 180.00 | |
| | | 2,123.50 |
| Total Receipts | | $2,317.17 |

### *Disbursements*

| | | |
|---|---|---|
| Transactions, 1927, Vol. 57, | | |
| Printing of (800 copies) | 750.75 | |
| Mailing Jackets for | 8.50 | |
| Postage for mailing of | 67.28 | 826.53 |
| 1927 Meeting at Hartford, Conn. | | |
| Reporting proceedings of | 275.00 | |
| Printing programs for | 19.75 | 294.75 |
| Expenses of the Secretary's office | | |
| Printing stationery, notices, circulars, envelopes, blanks and postage | 134.19 | |
| Clerical Assistance for | 75.00 | 209.19 |
| Expenses of Librarian, | | |
| Postage | 15.00 | |
| Clerical assistance for 1927 | 30.00 | 45.00 |
| Expenses of Treasurer's Office, | | |
| Postage and express | 6.13 | |
| Printing billheads and envelopes | 45.50 | |
| Clerical assistance for 1927 | 75.00 | |
| Bond Premium | 2.50 | 129.13 |
| Membership in National Conference on Outdoor Recreation | 10.00 | 10.00 |

| | | | |
|---|---|---|---|
| Transferred to Permanent Fund on account of Life Membership | 50.00 | 50.00 | |
| Bank Exchange on Checks | .20 | .20 | 1,564.80 |
| Balance on hand | | | $752.37 |

PERMANENT FUND

*Receipts*

| | | |
|---|---|---|
| Cash Balance on hand at meeting of 1927 | | $835.92 |
| Bank Interest to December 1, 1927 | $11.27 | |
| Bank Interest to June 1, 1928 | 10.00 | |
| Interest on Mortgage Certificate to June 1, 1928 | 82.50 | |
| By transfer from General Fund on account of one Life-Membership | 50.00 | |
| | | 153.77 |
| Total Receipts | | $989.69 |

*Disbursements*

| | |
|---|---|
| Transferring 40 shares Consolidated Railroads of Cuba, $2,810.00 to First Mortgage Certificate $3,000.00 at 5½% | $175.96 |
| Balance on hand | $813.73 |

As shown above, the assets of the Permanent Fund, therefore, total over $3800. The cash balance of the Permanent Fund is deposited in the National Bank of Commerce in Milwaukee.

In accordance with the action of the Society at the Hartford Meeting, a fund was started for publication of an index to the Society's publications with recommendation that as many of the members contribute to this fund as liberally as they can to insure the publication of such a desired work. $180.00 has so far been received. The list of the subscribers to date, with the amounts contributed respectively are as follows: Frederic Walcott $50; Nathan R. Buller $20; William C. Adams $20; Joseph F. Comee $15; Carlos Avery $10; Swepson Earle $10; E. Lee Le Compte $10; C. P. Peterson $10; Dr. Emmeline Moore $10; Thaddeus Surber $5; J. W. Titcomb $5; J. H. Otterson $5; Linus Leavens $5; Ed. F. G. White $5.

**Respectfully Submitted,**

**T. E. B. POPE,** *Treasurer.*

The report was, on motion, accepted, subject to the approval of the Auditing Committee.

# REPORTS OF VICE-PRESIDENTS OF DIVISIONS

## REPORT OF THE DIVISION OF FISH CULTURE

By James A. Laird

In considering the recent developments in fish culture I would recommend to all interested in fish rearing the careful study of the different papers and discussions presented at last year's Hartford Meeting.

The indiscriminate or carless drainage of swamp areas is detrimental to fish culture, in that it destroys plant growth and the breeding places of insectivora necessary to wild fowl and fish life. It also lowers the water table and is a direct cause of floods, allowing water to run off faster than if held by roots and vegetation. The flooding of such areas by building dams as is now being done in several states and the stocking of these reservoirs with game and food fish, with due provision for fish food, are the proper procedures. A year of intensive food production would insure results, that is, the setting out of pond plants by transfer of seed and the establishment of a stock of forage fish before the actual planting of the fish. Such ponds stocked with the common varieties of fish at the same time provide desirable fishing, improve the landscape, and hold the water back for the good of the farmer.

The stream surveys conducted by New York, New Jersey, Connecticut and other states are a long stride forward. In the past, millions of fish have been planted unadvisedly, because of adverse conditions of food, temperature, and enemies.

The work of Russell F. Lord, Jr., on a forage fish which is non-competitive with bass or other game fish, is a most noteworthy attempt to solve a problem paramount in fish culture. The black-head minnow, goldfish, golden shiner, or perhaps some other species, will help to check the cannibalism in fingerling bass, and can be applied to some extent in trout rearing, especially when trout are wintered in ponds.

The rearing of *Daphnia magna* as conducted at Hackettstown, N. J., by Charles O. Hayford, is unlimited in its possibilities as a natural food for young bass and other pond fish.

The extensive manufacture of medicinal liver extracts has caused an advance in the price of fish food to the financial disadvantage of the commercial trout grower. It is possible that the by-products of the livers so processed may be utilized for fish food instead of fertilizer, although the liver is so finely ground that it will require some binding constituent to make it applicable to other than fry feeding.

Too much stress is put upon the planting of large numbers of fish and too little thought is given to the conditions of environment in the way of food, temperature, and eternal enemies with which the fish have

to contend. Fish-eating birds, such as blue herons, night herons, bitterns, kingsfihers, etc., can do inestimable damage in a shallow stream or body of water. More fry and fingerlings are eaten by eels than we realize. Water snakes, snapping or mud turtles, lampreys, eels, and the common rat catch quantities of fish. Let us give the coon, bear, mink and otter all the fish they can catch, but let us destroy the useless enemies. Each state, private, or federal organization, where fish or game is reared or protected, should have an efficient method of vermin control. It behooves us to fertilize our waters as we do our farms, protect our fish as we do our chickens, and continually kill useless vermin. Then we may hope to come a little nearer to supplying the demand for fish.

I could mention the valuable work which has been done in testing the value of fish food by feeding experiments; the study of disease control; cooperative fish culture, which is one of the finest projects ever developed which every state should emulate; the timely shrimp investigation; and many other items of interest, but time does not permit.

## REPORT OF THE DIVISION OF AQUATIC BIOLOGY AND PHYSICS.

By George C. Embody.

### PRINCIPLES OF POND FERTILIZATION

The Vice President of the division of aquatic biology and physics feels that American fish culturists, more particularly those specializing in the propagation of warm water fishes, should make greater use of fertilizers in attempting to increase production in ponds and since very little has appeared in our Transactions pertaining to the underlying principles, he offers this brief account as his annual report.

In Central Europe various ways of manuring ponds have been practised for a great many years by the more progressive carp culturists and in the vast literature which has arisen the statement is frequently found that the production of carp has been more than doubled by judicious use of fertilizers.

One might gain the impression, since carp are not propagated in America, that the method of pond fertilization would not be so useful in American fish culture. But when we compare the natural food of the carp with that of the young bass, crappy, bluegill and yellow perch, it is evident that there is not such a wide difference. The carp may be to a large extent a vegetable feeder, but still 50 per cent or more of its food consists of microscopic and macroscopic animals such as protozoa, rotifera (wheel animalcules) smaller crustacea (Daphnia, Cyclops, etc.) worms and the larvae of insects. These also are the very groups from which bass, bluegill and others during their first year at least secure food.

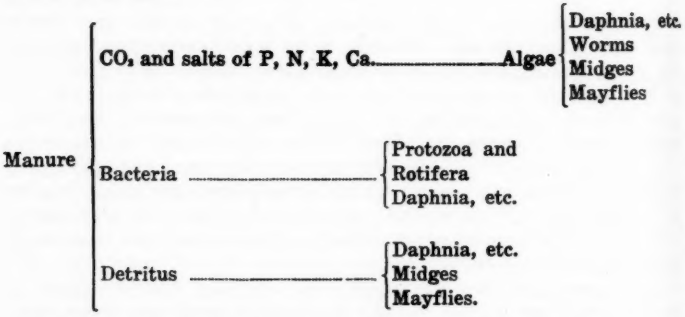
Pond fertilization tends to bring about a remarkable increase in the production of these organisms by a more or less indirect process. Various cycles of changes take place when manures are used. In the rotting process, bacteria are produced in enormous numbers with the attending liberation of carbon dioxide and various salts, namely, phosphates, nitrates and those of potassium and calcium.

The bacteria are devoured by the protozoa, rotifers and to some extent by smaller crustacea which in turn are eaten by the young fishes.

The carbon dioxide and the various salts are utilized by the micro-algae and to some extent by certain flagellates which are on the borderland between plants and animals. These in turn constitute the chief food items for many groups of minute crustacea of which Daphnia and Cyclops are important examples, for certain small worms and also for midges, mosquitoes and an important group of mayflies, (Callibaetis).

Still another process takes place. The manure is never completely rotted but some of it breaks up into finely divided material and settles to the bottom as an organic sediment called "detritus". This is believed to have considerable food value for the micro-crustacea and the larvae of insects.

Hence, in all three cases we start with manure and arrive at organisms constituting the chief food of fishes. The following schema will help to make this clear:—




**Food Organisms.**—In order to achieve the highest success with any particular fertilizer two things are of greatest importance, first, the necessity for stagnant water conditions and second, insuring the presence of mother organisms to start the culture.

The term stagnant water, does not mean foul or polluted water but merely quiet water which remains permanently in the pond. The ideal pond would have absolutely tight bottom and banks with just enough inflow to hold the desired water level and consequently is without outflow or seepage. The degree of success will be in direct proportion to the

degree of stagnation in the pond and those ponds which show the smallest amount of seepage or outflow will require the smallest amount of fertilizer. The reason is evident in that all outflowing water tends to leach out the fertilizing elements. If the outflow is very great, one may not expect to derive enough benefit to warrant the outlay of labor and fertilizer.

Insuring a supply of "mother" organisms is not a difficult task. Some of them such as bacteria, protozoa, rotifera and the micro-algae are usually present in the water supply, if it does not come directly from a spring. The various insects are attracted to the pond naturally. for egg laying. What definitely attracts them in numbers is not fully known, but it is generally believed that the odor of fermentation attending the decomposition of the manure is the important factor in the case of midges and mosquitoes.

By far, the best plan for insuring the presence of Daphnia and its relatives seems to be to start fairly pure cultures in small concrete basins and keep them on hand from year to year. Superintendent Hayford at the New Jersey State Hatchery has several such ponds in which fairly pure cultures of *Daphnia magna* are propagated in enormous numbers year after year to be introduced into the various rearing ponds as desired.

Usually there is a pond or lake not far distant in which one may find a mixture of various crustacea and algae, which may be collected with the ordinary towing plankton net of silk bolting cloth. These collections may be transported in small milk cans without difficulty and dumped into the ponds soon after application of fertilizers.

**Fertilizers.**—In central Europe, according to Haempel, they have had the greatest success with ordinary barnyard manure to which has been added water soluble superphosphates of calcium. It seems that almost all waters are deficient in phosphates and considerable increase in the amount of fish food results from its mixture with the manure.

At Hackettstown, New Jersey, Mr. Hayford has produced remarkable cultures with cow manure while others have used dried sheep manure with great success.

The late lamented Dwight Lydell secured a remarkable production of plankton crustacea by first using horse manure and later, at definite intervals, introducing clam meal.

In Europe the following results have been obtained with various mineral fertilizers. The addition of soluble superphosphates of lime always increased production. Saltpeter (nitrate of soda) did not increase production, because, according to Hofer's experiments, certain denitrifying bacteria destroyed this substance liberating the nitrogen into the air so quickly that it could not be used by the micro-algae. On the other hand distinct fertilizing effects were obtained with ammonium sulphate and calcium nitrate. Haempel states that by a thorough

fertilization with these substances, the productivity was increased 65.2 per cent.

The amount of fertilizer to use will depend to a large extent upon local conditions. Every pond culturist will have to experiment with different dosages in order to arrive at the amount which gives the best results. In a pond designed only for rearing young bass 1½ tons of horse manure per acre of pond would not be too much as a starter, and should be added about three weeks prior to the introduction of the young fish. One would ordinarily follow the intense treatment with one-half ton each succeeding month during the growing season.

Haempel says that superphosphate of lime is best used in quantities varying from about 267 to 400 lbs. per acre. It is dissolved in water preferably into three portions. The first is applied in the spring soon after the pond is filled with water, and the remainder at intervals of four weeks.

A great many bass culturists allow the breeding fish to spawn and rear the young in the same pond. In this case, caution must be exercised in the use of fertilizers, because manuring tends to reduce the oxygen and increase the carbon dioxide content of the water. If the oxygen is reduced too much, the bass will not spawn and even in case they should, the eggs might not develop. In this case the best plan is to apply a reduced quantity of manure very soon after the young have left the nest, followed by normal applications through the summer.

**Coarse Plants.**—The writer must confess a radical change of opinion in regard to the value of coarse vegetation in the rearing pond since he has been experimenting in ponds destitute of such plants. While unicellular algae are necessary links in the chain of events, leading to a dense culture of food animals, the higher plants including the pond weeds, water weeds, cattails, waterlilies and the like, cannot be considered anything but weeds. Experimentation in outside ponds both of concrete and earth construction shows that much denser cultures of plankton crustacea, midges, mosquitoes and even mayflies are obtained if the ponds are destitute of higher plants. These plants have two functions which tend to limit the production of food animals. They prevent the warming up of bottom water which means a retardation of the processes of decomposition and they compete with the micro-algae for nutritive substances. One will receive nowhere near full value for the fertilizer applied to a weedy pond. The largest portion is appropriated by the weeds which in turn serve no useful purpose important enough to compensate for their obnoxious characteristics.

Hence, the last important step to be taken in connection with successful pond fertilization is to eliminate higher plants entirely if possible, but if not so, to at least keep them in check by frequent cutting. The plant crop may be piled in cocks along the banks where it will rot and later may be returned to the pond as fertilizer.

## REPORT OF THE DIVISION OF PROTECTION AND LEGISLATION

By Lee Miles.

Mr. President: I want to recommend among some other important things for Legislative action a Federal law providing a penalty for polluting streams. The Government has taken jurisdiction tending toward the control of flood waters of some of the principal rivers of the nation. This is done on the theory that no one particular state is responsible for the creation of flood conditions and therefore, no one particular state would be able to control the flood situation. The waters of many states contributing to a flooded condition to the damage of the citizens of states, creates a condition that warrants Federal jurisdiction. The various pollutions of interstate streams by pumping into these streams material destructive to fish life from oil fields, mining industries, paper pulp mills and the like industries should be controlled by a Federal Act out of the same principle of law that warrants Federal jurisdiction in the control of floods.

There is wide-spread activity toward drainage of bayous, lakes, marshes and other waters for agricultural purposes, that do not serve the purpose for which the drainage was intended. We must have water areas for other purposes and these water areas should be maintained to supply fishes for commercial use as well as for food and recreation. The writer knows of many projects of this kind that have been failures from an agricultural standpoint, but at the same time ruinous to fish life. The drainage of bayous, lagoons and marshes along the Mississippi River Basin has lowered the water level a few inches. This water level should not be lowered below its present level, but on the contrary should be raised, even for agricultural purposes.

I also want to call your attention to the importance of laws for the protection of small fishes in waters where activity of commercial fishing is carried on. In many of these states the commercial fishermen destroy more fish than they take. They are not cautioned or required by law to protect the small fishes while they are carrying on their prosperous industry. The small crop of fishes is therefore wantonly destroyed. Proper legislation should be enacted prescribing the method of taking fish from streams, lakes and other waters so as to produce the least damage to the fishes which are not taken.

The bull frog and the turtle produce in the warmer waters of this nation a splendid supply of food and a certain amount of sport and recreation. So far as I am advised, no state has enacted any laws tending toward the protection of the bull frog and the turtle. This should be done.

A great deal of consideration has been given to the creation of refugees for migratory wild fowl. I think it would be an easy matter to set aside sections of streams and other water areas in which no fishing of any kind should be permitted. Suitable cover should be provided to protect fish in these areas, so that the fishes produced would tend to stock the other areas in which fishing was permitted.

Predatory fish, such as gar in the warmer states of this country, take a terrible toll of game fish each year. The gar at maturity will reach a length of seven feet, and weigh 180 pounds. It is through the warmer part of the year he takes his daily meal. Game fish have many enemies, among the most destructive of which are man and the gar. Without definite data, it is my opinion that predatory fish, such as the gar, take greater annual toll of adult bass than man.

## REPORT OF THE LIBRARIAN.

### By John W. Titcomb

The activities of the Librarian have been covered by both the Secretary and the Treasurer. We find an increasing demand for the publications. We have on hand quite a large number of copies of the Transactions for all years since 1894 except that of 1905, which is out of print. Any member may procure these publications. I imagine that eventually the Society may wish to have a reprint of that particular issue in order to be able to furnish complete sets. The Society itself has not a complete set of the Transactions, some of the earlier copies being lacking. The earlier volumes are merely thin pamphlets of little value to the present day fish culturist, except in an historical way. But we have some of them; for instance, a surplus of 1876. I hope that every member of the Society will keep his Transactions. It is unfortunate that so many valuable publications have gone to the waste basket after having been read by the member who received them. We are offering dealer's price for certain copies in order to get complete sets. A complete set of the Transactions is worth from $150 to $200.

During the past year we have arranged for the card indexing of the publications from 1870, when the Society began as the American Fish Culturists Association, to date. We had to borrow some of the copies of the Transactions from Harvard University library, presented, I believe, by one of our late lamented members, Daniel B. Fearing. Your Secretary has suggested subscriptions toward the cost of publishing the index. We already have some money for that purpose. If every member of the Society buys a copy of the catalogue at the estimated cost of five dollars when it is completed, we will have an appreciable sum. Too often we have a repetition of the same subjects or discussions at these meetings. The index will be complete in every detail as to authors and subject.

The woman who is doing the cataloging work has encountered some difficuties. From time to time authors' names have been published in different ways. For instance, the cataloguer who is a stranger to the work finds "James A. Henshall", "James Alexander Henshall". and "J. A. Henshall" at different intervals during a course of twenty or thirty years. Again she had the name of R. L. Ripple, H. L. Ripple, and Robert Ripple. Of course, when a man is well known we recognize the proper name, even when the initials of the same person differ with different papers. Professor Birge of Madison is credited with a paper which is so unlike Professor Birge that the printers must have shifted the names on the galleys. She says further:

"The names of the people who have written the articles, however, have not given me half as much trouble as the names of the fishes and other creatures which they have written about, and the airy, carefree manner in which they call two fishes by the same name, or one fish by half a dozen different names. I found it necessary to adopt a standard nomenclature from Jordan and Everman's "American Food and Game Fishes", since of course articles on one subject could not be permitted to scatter over the alphabet, simply because people writing on that subject adopted different names for the same thing. I could scarcely expect anyone to believe the amount of time it has been necessary to expend to straighten out the nomenclature on a single troublesome article. I have had to go to the Bureau of Fisheries and to the Library of Congress in some cases. The confusion is not always the fault of anyone. Scientific nomenclature has changed in the fifty-seven years since the American Fisheries Society was founded; what was *Salmo* alone has become *Salmo, Salvelinus* and *Oncorhynchus*, yet in many cases people writing at the same period use different names for the same fish, or, what is far more troublesome, the same name for different fishes, as "river herring" for *Pomolobus chrysochloris* and *Pomolobus pseudoharengus.*"

The publication of this catalogue is going to be an investment on which we will not get returns for many years. There will be a demand for it among libraries. I think that those who feel like subscribing to it even at say five dollars apiece, should be entitled to a copy free when it is issued. I think, too, we are warranted in drawing from what we may call the permanent fund over and above the original three thousand dollars, which we call the sinking fund, and for which, by the way, we are indebted to the people of the Pacific coast who raised that fund in 1915 when the meeting was held in San Francisco.

APPOINTMENT OF COMMITTEES

*Committee on Nominations*: Eben W. Cobb, Chairman; James A. Laird, I. T. Quinn, J. R. Dymond, N. B. Schofield.

*Committee on Time and Place*: Thaddeus Surber, Chairman; E. Lee Le Compte, C. P. Peterson, Lee Miles, N. B. Schofield.

*Auditing Committee*: Seth Gordon, Chairman; W. H. Thompson, Percy Viosca.

*Committee on Resolutions*: Carlos Avery, Chairman; John W. Titcomb, C. F. Culler, William M. Keil, S. H. Gray.

## REPORTS OF STANDING COMMITTEES

### REPORT OF THE COMMITTEE ON RELATIONS WITH NATIONAL AND STATE GOVERNMENTS.

MR. D. H. MADSEN (Utah): I was not aware that I was to report for this committee. As a matter of fact, I have been so very busy with other affairs that I hardly knew I was on the committee until it was called to my attention by our President. Therefore, I have no official report to present. However, it may not be out of place to make a few observations along the line of cooperation between state and federal departments in so far as the protection and propagation of fish is concerned. Naturally my remarks will apply particularly to inland fisheries, because I am not at all familiar with the operation of the coast fisheries.

The history of this work is interesting in that the expansion of operation has been so extremely rapid. Many of us who have been connected with departments of fish and game over a period of time recall when the first activities in the distribution of desirable food and game fishes was begun by the federal government. Even in my own lifetime, and I am only a boy yet, I had the pleasure of being associated with Dr. David Starr Jordan in his early work in classifying and collecting the fishes of the West. At that time there was little or no fish distribution, until the Bureau of Fisheries began its activities, and almost before we realized it desirable food and game fishes had been introduced into many of the waters of the country. The states soon interested themselves in the propagation and distribution of fish along the lines suggested by the federal government, and the work has now developed to a point where fish are distributed in millions all over the United States. I think too much credit cannot be given this Society and the United

States Bureau of Fisheries for their excellent scientific contributions which have made this work possible.

The need for cooperation between the federal departments and the states is apparent to everyone who is interested in the propagation and protection of fish and game. I am sure that no one in this country knows better than I the disastrous effects of misunderstanding and lack of acquaintance with others who are interested in the same work. A slogan which was used some years ago with success ran something like this: "Get acquainted with your neighbor; you might like him." From this sentiment grew the various civic organizations, service clubs, luncheon clubs, chambers of commerce, sportsmen's organizations, scientific bodies, until now we know our neighbor, and we find something good in him.

The state official has no argument whatever with the federal official once their activities are fully understood. About ten years ago, when I assumed control of the State Department of Fish and Game we had a federal fish hatchery operating in Utah, to which no attention had been paid by the state department. We discovered a haphazard method of collection and distribution of fish eggs from the natural sources of supply in our state, whereby an unfair proportion of the eggs collected in Utah went to adjoining states, because the head of the state department had not cooperated with the federal fish hatchery officials. Cooperation resulted in the ability of the state to get, through its representation in congress, an adequate appropriation for the operation of the federal hatchery. The federal hatchery, in turn, gave the state the benefit of all its scientific knowlege relating to fish propagation and distribution. For the last five or six years there has been the finest cooperation. The federal hatchery is now producing and distributing, owing to the aid of the state, at least ten times as many fish as formerly.

We do not object to a reasonable supply of eggs going out to other states, because we receive in return eggs from other states. Through this cooperation we have received many desirable fishes, such as the landlocked salmon of the East, the silver salmon of the West, catfish, yellow perch, and many other varieties.

I am certain that conservation of wild life will never be realized in this country under our present system of government until we have a complete and absolute system of cooperation between the federal government and the states, between the sportsmen's organizations of the country and the state game departments, and I think too much cannot be done to bring about this desirable result.

I am sorry I have not a detailed report to make, but I do beleive that as time goes on the work of this Society will be appreciated more and more throughout the country, and the results which we are all working for will be brought nearer achievement when we understand each other and each other's problems.

MR. EBEN W. COBB (Connecticut): I have been called on by the President to perform a duty which gives me great pleasure. We have with us today a member who has been connected with the Society for a long time, and he is soon to celebrate his ninety-second birthday. For most of his life he has been interested in fish culture. He has recently travelled from the Atlantic seaboard to the Pacific. Mr. Hurlburt, of Lynn, Massachusetts, to whom I refer, retains, I am glad to say, all his keenness of mind, strength of body, and sense of humor. I would like him to stand up so that you may greet him.

MR. H. F. HURLBUT (Massachusetts): It is a great pleasure to me to be here on the occasion of your conference. While circumstances have prevented my attending many of the meetings, I have never lost my desire to see the Society prosper. I have raised trout for a number of years. Years ago by taking eggs from selected fish I found that I could save one year in putting trout into the Boston market, which required four to the pound, but it was worth considerable to save a year rearing trout. The commercial hatcheries have a great opportunity to improve trout productivity. Why not improve the trout and other fish by selective breeding in the same manner as is being done with domestic cattle.

Communications were read from the President of the United States, Dr. David Starr Jordan, and Commissioner Doze of Kansas.

## REPORT OF THE AUDITING COMMITTEE

MR. SETH GORDON: Your Auditing Committee has examined, as carefully as an Auditing Committee can in the limited time available, the report of the Treasurer, Mr. Pope, and I am delighted to say that the accounts are in splendid condition. Very few societies of this kind can boast of better ones. The vouchers, cancelled cheques, etc., are all with the records, and we find that the state of the Society's accounts at this time as follows:

Balance on hand in the general account on July 13, 1928, $752.37. In the savings account, National Bank of Commerce, $813.73. In the permanent fund, or a sort of sinking fund, there is a certificate for $3,000, making a total of $4,566.10, as cash assets of the Society at this time.

We should like to suggest that it will materially aid the Auditing Committee next year if the incoming treasurer will prepare a brief, analyzed statement showing the income from various sources and the expenditures, with transfers for various purposes.

The report of the Auditing Committee was accepted.

## REPORT OF THE EXECUTIVE COMMITTEE.

MR. CARLOS AVERY: The Chairman of the Executive Committee, Mr. Spragle, asks me to present the report.

The matter referred to the Committee was the suggestion made by the Treasurer for an amendment to the by laws. The Committee reports that the 5th subdivision of Article 2 of the by-laws may with advantage be amended so as to read as follows:

"Life Memberships.—Any person may, upon a two-thirds vote of the members present at any regular annual meeting and the payment of fifty ($50) dollars, become a life member of this Society and shall thereafter be exempt from payment of annual dues. The Secretary and Treasurer of the Society are hereby authorized to transfer members from the active list to the list of life members, provided that no member shall be so transferred unless he shall make a request for such transfer and shall have paid dues as an active member for at least twenty-five consecutive years."

The change in that by-law is as follows—I will read the portion of the by-law changed:

"The President, Secretary and Treasurer of the Society are hereby authorized to transfer members from the active list to the list of life members at their discretion for good and sufficient reason, such as inability to pay dues, provided that no member shall be so transferred unless he shall have paid dues as an active member of the Society for for at least twenty-five years."

It removes the requirement that the active member shall be unable to pay dues and provides that he shall be transferred to the list of life membership on his own request after paying twenty-five years consecutively as an active member. The constitution and by-laws may be amended legally at any annual meeting provided there are fifteen members present and voting.

It is recommended by the Committee that the Publications Committee of the Society be expected to undertake the entire work of determining what papers shall be printed in the Transactions and to prepare the copy for the printing of the Transactions, including the editing of the papers and proceedings, the reading of proofs, and the doing of other work incident to the issuing of the annual Transactions.

The Committee further recommends that the recommendations of the treasurer that the offices of secretary and treasurer be combined in the interests of economy be approved. We do not find, however, that any change in the constitution and by-laws is necessary to accomplish this result.

The report and recommendations were accepted, and the recommended amendment to the by-laws adopted, more than fifteen members being present.

## REPORT OF THE COMMITTEE ON TIME AND PLACE.

MR. THADDEUS SURBER: I have the honor to report that the Committee on Time and Place have selected the city of Minneapolis, Minnesota, for the next meeting, the date to be the week beginning September 9, 1929. This choice has already been approved by the International Association.

The report of the Committee was accepted.

## REPORT OF THE COMMITTEE ON RESOLUTIONS

MR. CARLOS AVERY: The Committee on Resolutions begs leave to submit the following report:

1. The American Fisheries Society approves the fish cultural policy of the U. S. Bureau of Fisheries and its program of biological and technical research along practical lines; and urges the adoption by Congress of the five-year program recommended by the Committee on Merchant Marine and Fisheries at the last Session of Congress providing for the extension of the work of the Bureau of Fisheries.

2. In view of the growing menance to the fisheries through encroachments of hydro-electric developments on our streams, the American Fisheries Society urges that streams of real importance to the fisheries resources be determined and designated without delay and that such streams be withdrawn from further power development until urgent public need for such development is clearly shown, and until a known metnod whereby anadromous fishes shall not be interrupted in their nuptial journey, has been provided for without any doubt.

3. The American Fisheries Society strongly approves the efforts of the United States Bureau of Fisheries and the several states interested in the problem to devise an efficient method of preventing the enormous loss of fishes in irrigation ditches, and we urge that the efforts be continued until a satisfactory solution is found and applied.

It is also urged that sufficient appropriations be provided by Congress for similar investigation tending toward the solution of the fishway problem.

4. In view of the fact that many important fisheries in industrial districts have been destroyed by the pollution of the waters; and that other important fisheries are in imminent danger from the same source; and that the state of Pennsylvania has adopted a very effective method of dealing with this problem, it is therefore urged by the American Fisheries Society that similar methods be adopted by other states.

It is also recommended that the establishment on unpolluted waters of industries having injurious wastes be delayed until satisfactory methods of handling such wastes can be applied.

5. The American Fisheries Society recognizes the existence of the various fisheries conservation problems common to the United States and Canada,—in particular, of those relating to the salmon and fisheries of the Great Lakes, and recommends the immediate adoption of appro-

priate treaties looking towards the restoration of such international fisheries as are depleted and the adoption of uniform regulations where such are desirable; and to a closer cooperation in dealing with such matters.

6. The American Fisheries Society approves the work accomplished by the Western Food & Game Fish Protective Association through the cooperation of sportsmen, commercial fishery operators and others interested in the preservation of the fisheries; and urges a closer cooperation between these various interests throughout the country in securing constructive action on fishery problems.

7. WHEREAS, there has been an increase of considerable proportion in commercial troll fishing in the Pacific Ocean off the coast of Alaska, British Columbia, Oregon, Washington and California, during recent years; and

WHEREAS, there are many numbers of immature salmon taken, especially during the early spring months; and

WHEREAS, this has resulted in a depletion of the salmon supply; and

WHEREAS, it is evident that in the interests of conservation and perpetuation of a major industry that some remedial legislation is needed; now, therefore

*Be it resolved,* by the American Fisheries Society, in convention assembled, at Seattle, Washington, this 31st day of August, 1928, that the several legislatures of California, Oregon and Washington, as to their respective coasts, the Department of Marine and Fisheries of Canada, as to the British Columbia coast, and the U. S. Department of Commerce as to Alaska, be asked to pass uniform legislation or promulgate uniform orders that will regulate commercial trolling, and the landing of troll-caught fish, by the establishment of closed season periods.

8. The 58th Annual meeting of the American Fisheries Society has been marked by a most elaborate and efficient program of entertainment and no detail which might contribute to the success of the meeting or the comfort, pleasure and convenience of the members and delegates has been omitted.

For this elaborate and attractive program the Society has been indebted to the very enterprising, efficient, and active local arrangements committee, particularly to its chairman, Mr. Charles R. Pollock, its vice-chairman, Mr. S. F. Rathbun, and its secretary, Mr. Clinton W. Rowley.

We therefore extend our most sincere thanks and express our most sincere appreciation to this committee and also to the members of the Ladies' Reception Committee for the many courtesies extended to our members and the ladies in attendance at the meeting.

We also appreciate the courtesies extended by the Mayor and other officials and numerous citizens of the city of Seattle, by the various officials of the State Departments of Fisheries and Game, by the ladies of the Presbyterian Church of Auburn at the Green River hatchery, and by the press of the city of Seattle.

The report of the Committee was unanimously accepted.

MR. TITCOMB: In view of the unusual expense involved in preparing the catalogue of the Transactions of the Society from its inception to the present day, I move that the President and Secretary be authorized to incur such expense as is necessary without infringing upon the sinking fund.

The motion was carried unanimously.

## REPORT OF THE COMMITTEE ON NOMINATIONS.

**OFFICERS FOR 1928-1929:**

*President* ..... C. F. CULLER
*Vice-President* ..... DR. DAVID L. BELDING
*Secretary* ..... CARLOS AVERY
*Treasurer* ..... CARLOS AVERY
*Librarian* ..... JOHN W. TITCOMB

*Vice-Presidents of Divisions*

*Fish Culture* ..... JAMES A. LAIRD
*Aquatic Biology and Physics* ..... DR. H. S. DAVIS
*Commercial Fishing* ..... JOHN P. BABCOCK
*Angling* ..... WILLIAM M. KIEL
*Protection and Legislation* ..... E. LEE LECOMPTE

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*Committee on Foreign Relations*

LEWIS RADCLIFFE
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DR. C. M. FRAZIER

*Committee on Relations with National and State Governments*:

W. A. CLEMENS
HENRY O'MALLEY
JOHN W. TITCOMB
CHAS. R. POLLOCK
FRED A. WESTERMAN
DR. V. K. IRION

*Publications Committee*:

DR. DAVID L. BELDING
JOHN W. TITCOMB
DR. GEORGE C. EMBODY
DR. H. S. DAVIS

The report of the Committee was adopted and the nominees declared elected.

RETIRING PRESIDENT MOORE: I congratulate you on behalf of the members of the Society, Mr. Culler. I assure you of the loyal support of the members. I have experienced it during the past year, and it is a part of the heritage of every new president.

PRESIDENT-ELECT CULLER: Members of the American Fisheries Society, I want you to know that I am deeply appreciative of the honor you have conferred upon me, and I will bespeak your loyalty in the coming year in an attempt to make it equally as profitable as the past year has been. If there is no further business to come before the meeting, a motion for adjournment is in order.

Whereupon, the Fifty-eighth Annual Meeting of the American Fisheries Society was adjourned.

# In Memoriam

## CHARLES HENRY GILBERT

By John P. Babcock and William F. Thompson

The life of Dr. Charles H. Gilbert spanned an important period in the history of commercial fisheries, from his birth in 1859 to his death in 1928. This period has seen the development of these fisheries into great industries. With this development have come great and urgent problems of conservation, calling for the application of scientific research, exact and difficult. It has been the indispensable service of Dr. Gilbert, that he has led in this application in America, and that he has greatly furthered it through his students.

Dr. Gilbert came to rank as one of the greatest and most productive systematic ichthyologists of his time, distinguished by the exactness and accuracy of his work upon American fishes and others. As a young man with Dr. David Starr Jordan, he made the first fisheries survey of the Pacific Coast and published with him and alone, many papers on Pacific fishes. This knowledge of fishes and their relationship formed an indispensable foundation for his later fundamental work upon the life history of the Pacific salmon and underlying all protective legislation upon salmon will be found his development of the home stream theory of their migrations, a development which resulted from his study of the age marks on scales. But the most important contribution he brought to these studies of life history were his high ideals of scientific method, his inspiring and complete devotion to his work, the clarity and severity of his methods of reasoning. These things, his knowledge, his method and his scientific personality, remain as permanent influences among his students and his associates.

Through his nearly lifelong term as professor of zoology at Stanford and through the important faculty posts he held there, Dr. Gilbert left a permanent personal impress upon the many that came in contact with him. His austerity and justness were underlaid but not weakened by an affectionate nature and versatile mental gifts that endeared him to all who knew him well. In his last years, as professor emeritus, active and aggressive in his salmon studies, yet under the constant threat of paralysis, his contact with his friends and former students was genial, full of enjoyment and interest. He died in the midst of accomplishment, his mental life flowing full and unafraid to the end, his spirit indomitable and undaunted by approaching shadows.

**GEORGE A. BUCKSTAFF**

**BASHFORD DEAN**

**HOWARD ELLIOTT**

**G. HANSEN**

**E. LESTER JONES**

**F. P. KENDALL**

**W. McDONALD LEE**

**AMY H. MARVIN**

**GEORGE E. POMEROY**

PART II

# PAPERS AND DISCUSSIONS

# ALASKA SALMON—AN ACHIEVEMENT IN CONSERVATION

By Henry O'Malley

*United States Commissioner of Fisheries*

It is indeed a pleasure for me to have the opportunity of attending again a meeting of the American Fisheries Society, especially on the Pacific coast, a section of the country which has become mine by adoption.

In the front rank of the food fishes of the world a prominent place is taken by the Pacific salmon. This valuable and wholesome product finds its way into every quarter of the globe and is universally accorded a high place in the food supply of mankind. Not only is the salmon, whether eaten fresh, mild cured, smoked or canned, a toothsome product, but it is one that is particularly valuable in maintaining a well balanced diet, especially because of chemical constituents and body-building materials more or less lacking in other foods.

The demand for salmon, particularly the canned product, has grown steadily from the time the first can of salmon was put up on the Sacramento river in 1864 to the present date when the industry is one of the most important on the Pacific coast and especially in Alaska. The normal production of canned salmon in the Pacific coast states and Alaska in recent years has averaged approximately six million cases annually, of which Alaska produces an average of nearly five million cases valued at about forty million dollars.

In Washington, Oregon and California, the state authorities have control over the salmon fisheries, although the federal government is deeply interested through fish-cultural operations and scientific and economic investigations. In Alaska, however, the federal government has full jurisdiction, apart from license taxes imposed by the territory. Under the White Fisheries Law of June 6, 1924, broad powers were given the Secretary of Commerce to say when, where and how fishing may be conducted in Alaskan waters. These activities are administered through the Bureau of Fisheries.

Prior to the enactment of the law of 1924, the salmon fisheries of Alaska had suffered a serious decline through intensive overfishing. The salmon canning industry, which in Alaska had its inception in 1878, grew to such an extent

and was prosecuted with such vigor for many years that the future of this highly valuable natural resource was seriously threatened. The laws were inadequate to meet the situation and conditions were truly critical when the new law of 1924, sponsored by secretary Hoover, became effective. Regulations to curb excessive fishing and apply necessary restrictions where required were immediately promulgated for the season of 1924.

The plan adopted was to divide Alaska into eight fishing areas, since increased to twelve, wherein regulations designed to meet varying local conditions were put into effect. These measures were primarily along the line of applying closed seasons, extending weekly closed periods, fixing the size of mesh, limiting length of nets, fixing distance intervals between traps, prohibiting certain types of apparatus in specific localities, and closing certain waters to commercial fishing, especially around the mouths of streams where salmon assemble in compact schools before ascending the streams to spawn. While in these restricted waters, they are easily caught by purse seines and other movable types of fishing gear. In order to prevent the entrance of poachers into the closed areas in the vicinity of stream mouths, the system has been adopted in recent years of placing guards at the mouths of important streams, thereby insuring an adequate escapement of breeding salmon.

In connection with the enforcement of the fisheries laws and regulations, the Bureau posts notices at or in the vicinity of the mouths of salmon streams and closed areas to show the limits where commercial salmon fishing may be lawfully conducted. There are approximately 1,200 streams in Alaska which require attention of this character. The notices are an aid both to the fishermen and to those engaged in conservation activities, as all doubt is removed as to where fishing may be conducted. The prevention of invasions of closed waters is beneficial, not only in securing a better escapement of breeding salmon, but at the same time it lessens the expense of prosecutions for violations of the law.

Another feature of the Bureau's work of conserving the salmon fisheries of Alaska is the removal of natural barriers which impede salmon in their ascent of streams to the spawning grounds. Log jams are cut away and falls are made passable so that fish can continue upstream. The fisheries industry has co-operated in this work.

In its conservation program it has been the policy and aim of the Bureau to allow as much commercial fishing as pos-

sible, having due regard to the interests of an adequate breeding escapement in order to maintain the runs at their maximum productivity. True conservation is maximum use without impairment of the future. When the White Law went into effect near the beginning of the fishing season of 1924 it was known that various waters had been more or less heavily overfished. In order, however, to avoid to the fullest practicable extent any immediate marked disturbance of an established industry, the regulations as first promulgated were conservative in character. From time to time warnings were given to the trade that more drastic restrictions upon fishing might be necessary. In spite of this, expansions in fishing activities continued unabated and the average catch per unit of fishing gear showed a corresponding decline.

This was particularly the situation in Southeastern Alaska in 1927 when an extensive increase in the number of fish traps occurred. At the same time, in that season, there was a marked falling off in the commercial catch of salmon. In consequence, when regulations for the season of 1928 were promulgated, drastic curtailments in fishing, particularly in the operation of traps, became necessary. The policy was adopted of excluding this type of fishing apparatus from bays, estuaries, and narrow channels. It has resulted, in 1928, in a reduction of approximately 30 per cent in the number of fish traps and it has helped the situation materially. Further restrictions will be applied if at any time it becomes apparent that such action is necessary in order to properly conserve the salmon fisheries of Alaska.

It is the constant aim of the Bureau in all of its activities in conserving the Alaska salmon to insure compliance with the requirement that there shall be an escapement of not less than 50 per cent of salmon to the spawning grounds. Under the existing statute, commercial fishing is not permitted in rivers or within 500 yards of their mouths excepting the Ugashik and Karluk Rivers, where local conditions warrant such operations under proper restrictions. The law provides that nothing shall prevent the taking of fish for local food purposes or for use as dog feed in any of the streams of Alaska. This wise provision enables the native residents as well as various whites to supply themselves with one of their staple articles of food.

In its work of conserving the salmon fisheries of Alaska, the Bureau maintains a fleet of fifteen patrol vessels and during the active season upwards of two hundred persons

are employed for the protection of the fisheries. Two hatcheries are maintained and scientific investigators are constantly studying the life history and habits of the salmon, herring, clam, and other forms of aquatic life in Alaska, thus increasing knowledge in respect to these valuable resources and also enabling the co-ordination of results of these inquiries with practical problems of conservation.

The future of the salmon fisheries of Alaska is most promising. There is no reason whatever why this industry which gives employment to approximately 20,000 persons and yields products worth about forty million dollars a year on the average, should not be maintained at that level in perpetuity. It is believed that progress, particularly since 1924, has been made in bringing about this desirable end, and further progress along the same line is assured.

The situation which has existed in Alaska during the present summer has been most encouraging. The pack, as the figures will probably show at the end of the season will approach nearly five and a half million cases. This production is above the average pack and means that the fishery has been in a healthy condition during the present year.

Another bright spot even in this large pack is the fact that the spawning beds seemed to indicate that we were going to have an excellent seeding. Reports I have received from southeastern Alaska and westward to Bristol Bay, where the pack amounted to 1,300,000 cases odd of red salmon, indicate that notwithstanding the large pack we have had a fairly good escapement. The whole situation looks hopeful and healthful, and with the co-operation of the people in the industry and the people living in Alaska we hope to be able to maintain the supply so that we shall have salmon for years to come.

*Discussion*

SENATOR JONES: (Washington) : I am glad to note Commissioner O'Malley's optimism with reference to conditions in Alaska. Perhaps you know that he has been using his utmost efforts to bring about a stable and permanent condition in the fishing industry in Alaska. We passed legislation four or five years ago which we hoped and believed would result ultimately in the permanency of the fishing industry there. I consider that Commissioner O'Malley is more responsible than anybody else for that legislation, and for the results which in my judgment are bound to ensue by its efficient administration. I am confident that, if it is administered in the interests of the fishing industry, it will result in the assurance of a permanent fish supply in Alaska.

I appreciate some of the problems that Mr. O'Malley has had to deal with. We are all more or less selfish. Selfishness is the basis of a great deal of our progress and our development, and it is not surprising that we find this element to a strong degree among our fishing people. I have felt, however, that Mr. O'Malley has dealt with this phase of the situation in a fair, just and wise way. No doubt he has not been able to meet the demands of the fishing people. I feel satisfied that his chief consideration has been to ensure a permanent fishing industry and fish supply in Alaska, and so far as I could do so I have supported him in that policy. The primary consideration, not only for the nation as a whole but for the industry itself, is permanency of the fish supply which means permanency of the industry.

# A CANADIAN-AMERICAN SALMON RECLAMATION PROJECT

By John Pease Babcock

*Chairman International Fisheries Commission.*

The sockeye salmon fishery of the Fraser River System was once the most productive salmon fishery in which Canadian and American fishermen engaged. No other salmon fishery was so speedily developed. No other reached such a wealth of production. No other was so speedily destroyed. No other afforded so promising a field for exploitation. Its restoration is the greatest reclamation project in which Canada and the United States can jointly engage.

The history of the development and the destruction of the sockeye salmon fishery of the Fraser River System is one of the most calamitous fish stories ever told. Notwithstanding that the story is hackneyed no version of it has appeared in the Proceedings of the American Fisheries Society. It is the purpose of this paper to fill that void.

The sockeye fishery of the Fraser River System was and is an international fishery. The term "Fraser River System" includes all the waters in British Columbia and the State of Washington which are frequented by sockeye salmon. It includes all the waters of Juan de Fuca, Rosario and Haro Straits, the Gulf of Georgia. and the channels of the Fraser River frequented by sockeye salmon in their migrations.

The history of the sockeye fishery of the Fraser River System has been faithfully recorded. The records of no other fishery are as complete.

The Annual Reports of the British Columbia Fisheries Department since 1901 and those of three International Commissions which investigated conditions in 1905, 1908 and 1918, demonstrate that the sockeye salmon that formerly frequented the waters of the Fraser River watershed in vast numbers were hatched in the Fraser River watershed in B. C., lived for their first year or more in its lake waters, then migrated to sea, where they remained until the summer of their fourth year and then sought to return through Canadian and United States waters to that river to spawn, and after spawning died.

Because all the sockeye caught in the Fraser River System have been canned, the pack records afford an accurate meas-

ure of abundance. The outstanding fact in the records, other than that of depletion, is the former four-year periodicity in abundance. From the beginning up to and including 1913, the pack records show an astonishingly large pack every fourth year—known as "the big year", —and relatively small packs in each of the three following years —known as "the small years",—a condition that has no counterpart in any other waters. The periodicity in abundance is made plain by reference to the packs in the "big years" and in the "small years". In the big years 1897, 1901, 1905, 1909 and 1913 the pack averaged 1,777,585 cases. The packs in small years in the period 1894-1900—a period before depletion was manifest in the small years—produced an average pack of 542,597 cases.

Commercial fishing for sockeye salmon began in a small way in Canadian waters in 1876, with a pack of less than 10,000 cases. Fishing was confined to the channels of the Fraser River up to 1890 and gill-nets alone were employed. Gill-net fishing was extended to the discolored salt waters off the mouths of the river in 1890. Up to that year only the Canadian fleet was engaged, the market was limited and the catch in any one season did not produce a pack in excess of 183,000 cases.

Commercial fishing for sockeye salmon began in the State of Washington waters of the system in 1891, with the installation of traps in the vicinity of Point Roberts. Proving most effective, the number of traps employed increased rapidly and became the leading factor in 1897. Purse-seines came into use in American waters in 1901 and have since that year been extensively used. Since 1901, with one or two minor exceptions, the yearly catch in American waters of the system has been in excess of 60 percent of the total catch.

Production in the system in the big years of each four-year cycle reached its height in 1913 with a total pack of 2,392,895 cases, containing the edible portion of over 25,000,000 individual sockeyes. In 1917, the big year following the record high pack of 1913, the pack fell to 559,702 cases, a drop of close to 77 per cent. Since 1917 the packs in the big years of each four-year cycle have not exceeded 148,000 cases and can no longer be distinguished by their size from the packs of the three small years. There has been no periodicity in abundance since 1917. The glory of the Fraser has been destroyed.

The catches in the small years of each cycle up to the period 1898, 1899 and 1900 display no evidence of depletion.

In each of those small years the pack averaged 648,912 cases. From then on the packs in the small years rapidly declined. In each of the last eight years the total pack in any one year has not exceeded 159,000 cases. In the year 1923 it fell to 79,057 cases. The pack in the last eight years has averaged but 123,372 cases. Furthermore the bulk of the pack in recent years has consisted of late running fish,—runs that were not drawn upon prior to 1914.

The factors that so speedily destroyed the sockeye run to the Fraser River System are easily determined. In 1901 the Fisheries Department of the B. C. Government inaugurated a system of inspecting the entire spawning areas of the Fraser River. An annual inspection has been made and reports published. Year after year, since 1901, these reports have called attention to the significant fact that the greater proportion of the vast spawning beds of the Fraser River basin were but lightly seeded in each of the small years and in all the big years since 1909.

The late Dr. Gilbert, the cleverest of all fishery investigators, in one of his classic "Contributions of the Life-History of the Sockeye Salmon" published in the Reports of the British Columbia Fisheries Department, states that—"The history of the Fraser River sockeye shows unmistakably that the three small years of each cycle were overfished early in the industry. During the early years, when fishing was confined to the region about the mouths of the river and drift-nets alone were employed, no evidence exists of overfishing. The last cycle in which these conditions obtained was 1894-1896. During each of the small years of that cycle there were packed approximately 350,000 cases on the Fraser River and about 60,000 cases in Puget Sound. During each of these years, therefore, about five million sockeye were taken from the spawning run. . . . Apparently, however, a third of a million cases a year could be safely taken, for the following cycle shows no decrease. During the following period of four years (1897-1900) the traps in Puget Sound became an important matter. While the B. C. pack showed little or no reduction, it was now met by a pack on Puget Sound which nearly equalled it. The total catches during the three off-years of that cycle nearly doubled those of the preceding cycle and exacted an average toll of about 10,000,000 fish from the spawning run of 1897-1900. The total pack of the three small years of that cycle was over 2,000,000 cases.

"The result was quickly apparent. . . . The small years of the following cycle showed such a marked decline as to indicate that we had far overstepped the line of safety. It was then

during the cycle of 1897-1900 that the first serious damage was done to the sockeye run of the Fraser. By doubling the pack of the three small years, not only was the surplus fully taken but the necessary spawning reserve was seriously encroached on—with the result that in the small years of the following cycle (1902, 1903 and 1904), in spite of the increased amount of gear employed, the pack was cut in half, while the spawning-beds at the same time were but sparsely seeded.

"The inevitable and disastrous trend of events should have been evident to the dullest. But the parties in interest refused to hold their hands and proceeded with the slaughter of the spawning remnant."

Turning now to the decline in the runs in the big years. The records are equally clear. As already stated, the sockeye runs in the big years 1897, 1901, 1905, 1909 and 1913 produced an average pack of 1,777,585 cases, and it should be noted that the catches on both sides of the line in 1901 and 1905 exceeded the canning capacity and several millions of fish were wasted.

Up to and including 1913 the packs in the big year show no evidence of an overdrain on the spawning runs. The B. C. Fisheries report for 1913 shows that the escapement that year was as great, if not greater than the preceding big year, 1909—the brood year of the 1913 run. But that report also shows that the escapement in 1913 met with disaster and that comparatively few sockeye reached the spawning beds that year, with the result that four years later—1917—the pack fell to 559,732 cases, or close to 77 per cent less than in 1913. In 1921 it dropped to 142,598 cases; a drop in eight years of 2,250,297 cases.

The escapement in 1913 did not reach the spawning beds for the reason that the river's channel above Yale—known as Hell's Gate Canyon—was virtually closed to the passage of fish by a great rock slide. Millions of fish that had escaped capture and reached the obstruction in Hell's Gate Canyon were unable to pass over it, notwithstanding that strenuous efforts were made to enable them to do so. After frantic and continuous efforts to overcome the obstruction the fish became exhausted and were swept downstream, where they died without spawning. The Report of the B. C. Fisheries Department for 1913 deals exhaustively in both text and illustration, with the subject. That report shows that the number of sockeye that reached the spawning beds above Hell's gate Canyon in 1913 was less than an eighth of the number that reached the beds in 1909. This is made manifest by brief reference to the spawning bed reports for 1909 and 1913. In 1909 four million adult

sockeye were counted as they entered Quesnel Lake, one of the great lakes in the Fraser basin above Hell's Gate. In 1913 a similar count records that only 550,000 entered the lake. The spawning report of the B. C. Fisheries Department for 1913 concludes with the following words:—"The foregoing statements warrant the conclusion that the number of sockeye that spawned in the Fraser watershed this year was not sufficient to make the run four years hence even approximate the runs of either 1905, 1909 or 1913". The accuracy of that forecast and the disastrous effects of the 1913 blockade were made manifest on the fishing grounds in 1917. Notwithstanding that far more fishermen and more fishing gear were employed and a much higher price paid for the fish on both sides of the line in 1917, the total catch produced a pack of but 559,732 cases, as against 2,392,895 cases in 1913.

From then on conditions became even worse. Had the six millions of individual sockeye that made up the pack in 1917 been permitted to reach and seed the spawning beds in that year, some of the loss occasioned by the 1913 blockade could have been recovered. But such was not the case. The authorities, the fishermen and the canners on both sides of the line did not heed the warning in the reports of 1913. No additional protective measures were enacted and the fishermen and canners spared no efforts to capture every last sockeye in the run of 1917—with the inevitable result that the escapement of that year was no greater than it had been in recent small years. In consequence, the spawning beds produced no greater returns. The catch four years later, 1921, produced a pack of but 142,598 cases.

The sockeye salmon fisheries of the Fraser River System were not destroyed by the parties in interest without vigorous protest from fishery authorities on both sides of the line. As early as 1905 a joint commission, representing Canada and the State of Washington, after a full investigation of conditions unanimously recommended the cessation of all sockeye fishing in the system in the small years 1906 and 1908. The Commission expressed the opinion that by so doing the runs in the following cycle years would be materially increased. The closing was to be an experiment; the runs at that period had not been reduced to a low level. The government of Canada accepted the suggestion and passed the necessary enabling act. A similar act failed to pass the Legislature of the State of Washington and Canada repealed her act. Everyone concerned went after the fish harder than ever.

In 1908 an international commission was created to study conditions. Following its unanimous report and recommendation, Canada and the United States drafted a treaty providing for the preservation and propagation of sockeye in the Fraser River System. The government of Canada promptly ratified the treaty. The President transmitted the treaty to the United States Senate. After two years delay the Senate refused to concur and the treaty was withdrawn.

Then came the disaster of 1913 and renewed efforts to secure international intervention. In 1918 Canada and the United States again appointed a second international commission, headed by the Chief Justice of New Brunswick and the Secretary of Commerce of the United States. In accordance with the unanimous recommendations of that commission a second treaty was drawn which provided for "the times, seasons and methods for sockeye fishing in the Fraser River System" and "for the conduct of investigations into the life-history of the salmon, hatchery methods, spawning ground conditions, and other relative matter".

That treaty was promptly approved by the government of Canada. The United States Senate again refused to concur and the President withdrew it.

Nothing has since been accomplished. The pitiful remnants of the former abundant runs to the Fraser are still being preyed upon by Canadian and United States fishermen, and the vast spawning areas of the Fraser basin remain unseeded and unproductive.

The Fraser River basin contains 1,514,000 acres of spawning area. That area has not been lessened or contaminated. It is as extensive and as suitable for the propagation of the sockeye as formerly. The vast lake waters of the Fraser are as rich in the natural foods for young sockeye as ever. The channels of the river are open and free to the passage of such fish as are permitted to enter them. All that is required to produce the abundant runs of former years is a sufficient number of fish to seed them as abundantly as they were seeded in those years. No other waters afford so alluring a field for exploitation.

The restoration of the sockeye salmon fisheries of the Fraser River System is the greatest reclamation project in which Canada and the United States can jointly engage.

*Discussion*

MR. J. W. TITCOMB (Connecticut): Have any efforts been made to fill in by artificial propagation the runs in years other than the fourth year when the large run occurs.

MR. J. P. BABCOCK: The Dominion government began propagating salmon in the early days and is still operating hatcheries. It is hatching all the sockeye eggs in the Fraser River that can be obtained, but it has abandoned five of the hatcheries because of inability to get eggs. Eggs have been imported from other streams, as the Skeena and the lower Fraser, notwithstanding the fact that the American catch has been 60 to 70 per cent of all the fish. Canada stands prepared today to do her share. The province of British Columbia will do her share. All we want is cooperation. When the Fraser River had a pack of 2,300,000 cases of sockeye salmon she exceeded Alaska's pack of reds, and furthermore the Fraser River pack was the finest quality of sockeye that had ever been packed. It brought more money in the market than the salmon from Alaska or any other stream. If the United States and Canada will get together and really do something they have an opportunity to make $30,000,000 for the Canadian and the American fishing industries.

MR. J. W. TITCOMB: Is it not a fact that the disaster in 1913 which so materially reduced the run of the salmon is an impending disaster which this part of the country faces with the promotion of hydraulic developments and the erection of high dams?

MR. J. P. BABCOCK: There has been a great deal said about the conditions in Hell's Gate Canyon which brought about the disaster of 1913. The government spent many thousands of dollars in removing 220,000 odd cubic yards of rock from the bed of the stream. Since 1914 the Fraser River canyon has not been blocked to sockeye salmon. I began the study of conditions on the Fraser River in 1901, and annually have devoted considerable time during the run to the study of the condition of the fish. Hell's Gate was the first place where we had an opportunity of judging of the escapement. In 1913, in spite of the bad conditions in the Gate, millions of fish got through but they were blocked three or or four miles above by the slide. Dominion officers most familiar with these conditions, who made inspections every day during the time of the run, hold the view that they are as good as ever. I do not believe that any strong, healthy sockeye, which can reach the Gate now, does not get through. It is nothing unusual for the Fraser at that point to rise from 20 to 30 feet and to drop even from 20 to 30 feet in 24 or 36 hours. The fish were commonly delayed there before 1913, but the obstruction has been removed. There are no other obstructions in the watershed of the Fraser River. No water is diverted for irrigation

from the Fraser River basin since the river is so far below the level of the country through which it flows that the water cannot be used for the land. Its power resources have never been drawn on. If they draw on the river for power they will only use tributaries, which the sockeye have never frequented. So I say that the watershed of the Fraser River is just as suitable for the production of fish now as it ever was.

SENATOR JONES (Washington): I am heartily in accord with the sentiments expressed by Commissioner Babcock in his excellent paper. I had a conference on this subject with the Secretary of State just before leaving Washington and I think I am safe in assuring this Society that a treaty will be ready to present to the Senate at the opening of the next session of Congress which will deal properly with the sockeye situation.

MR. J. P. BABCOCK: I desire to thank Senator Jones for this statement and to express my appreciation of his great assistance in Washington in connection with this treaty. In addition our halibut treaty is largely due to his efforts. I can only inadequately express my joy at the idea that the United States will pass the treaty. When it is accomplished, I can die in peace.

# PROPAGATION'S PART IN THE CONSERVATION OF SOCKEYE SALMON

R. E. FOERSTER.

*Biological Board of Canada.*

The problem of the Fraser River Sockeye Salmon has been, during many years, the cause celebre for continued report and unbounded discourse. Interest in it has been confined to the Pacific Coast, to the Province of British Columbia and the State of Washington, but, of late, the exigencies of the situation have caused it to be broadcast throughout the world. Authoritative opinions and unofficial theories, made public and bandied about, have been so contradictory and have constituted such a heterogeneous body of information that, to the casual observer, the reactions must be most confusing and complex. From a scientific point of view, it would seem desirable, therefore, to survey the situation, define the conditions prevailing and canvass the possibilities for restoration.

The situation of the Sockeye fishery can be briefly outlined. At one time and up until a decade and a half ago, the Fraser River produced immense hordes of salmon of which the choicest and most prized were the Sockeye. As Simon Fraser related in his journal of August, 1792, "the run of salmon ascending the river was very large. They were driving up the current in such large shoals that the water seemed, as it were, to be covered with the fins of them." Each summer they entered from the marine feeding banks in countless thousands and spread throughout the immense drainage basin of 91,700 square miles to spawn. Today, the Sockeye, while still the choicest and most prized, are the least numerous and confine themselves to definite and limited spawning areas which have continued to remain productive in spite of the rapid and devastating depletion of the river as a whole. The decline is clearly portrayed in Figure 1 where are plotted the annual packs, reckoned in cases, from 1895 to 1926 for (1) the Fraser River, (2) Puget Sound, and (3) British Columbia and Puget Sound. In order to obtain complete returns for the Fraser it is necessary to include the pack from Puget Sound which is so largely made up of Sockeyes bound for the Fraser River. To what extent the latter pack includes Sockeye bound for American rivers is unknown but for purposes of comparsion the Puget Sound and Fraser River packs are usually taken in toto.

The information elicited from the graph is quite obvious. The most striking feature is the sudden decline in 1917 and its persistence, fully as disconcerting as the phenomenal yields of the big years, 1901, 1905, 1909, 1913, were pleasing. Furthermore, whereas during the first period, 1895 to 1907, the Fraser and Puget Sound packs were more or less equal, during the next ten years the Puget Sound pack greatly exceeded the former, to culminate, in the final nine years, in a more or less equal pack for each area. At the same time, it is found that while up to 1917 the total pack of British Columbia and Puget Sound was composed largely of the packs of Puget Sound and the Fraser, during the succeeding years, these latter formed only a comparatively small part of the total pack. At present, then, we find a fishery brought down, apparently through too intensive exploitation, to a fraction of its former productivity, each of the component areas being likewise affected.

It should not be inferred, however, that nothing has been done to curtail this ruinous exploiting or to avert the otherwise inevitable end-point. Factors bearing upon the Sockeye industry may be considered as depletory and remedial. Both by regulation of fishing and by artificial propagation, efforts have been made to restore the sensitive balance between supply and drain, to bring about that ideal state of conservation involving the greatest development and use of a fishery compatible with definite assurance of a proper perpetuation of supply. In so far as these two factors, regulation and propagation, have been successful, they may be considered as remedial; in so far as they have failed to fulfill their purpose, they must be termed depletory.

With regard to regulation, defined by Calderwood[1] as legislation enacted "to counteract the natural tendency of man to overfish, to capture fish at a harmful time or in a harmful way or to erect engines which obstruct the ascent of the salmon and facilitate their capture in undue numbers," efficient application of just laws is, in the present state of affairs, impossible. The fact that the Sockeye salmon problem of the Fraser is an international one should be stressed. The significance of this feature has been shown above in the discussion of the graphical history of depletion. It is equally if not more important when considered with regard to regulation. In an international situation of this kind, legislation on either

[1]Calderwood, W. L., 1908. The Life of the Salmon with reference more especially to the Fish of Scotland. London.

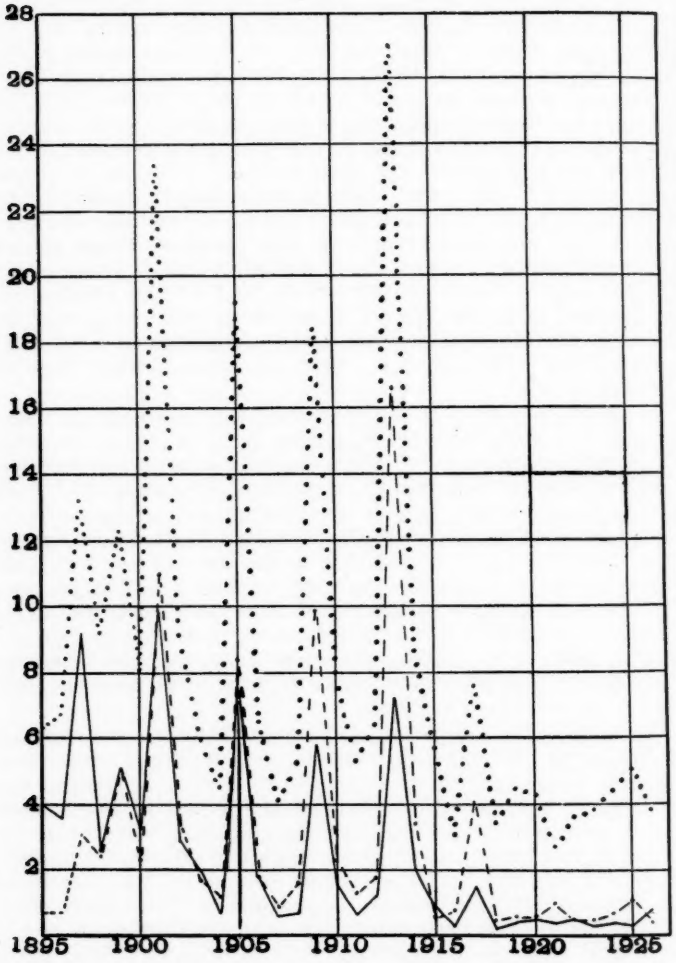



Figure 1. Graph showing the packs in cases for the Fraser River ( ———— ), Puget Sound ( - - - - - - - ), and British Columbia and Puget Sound ( . . . . . ). Each vertical space constitutes 200,000 cases.

side of the border may be uniform or may be in direct variance. Legal attitudes, practical viewpoints frequently differ and may lead to entirely opposite ends. In such an instance a treaty forming the whole river system into one common area, controlled by an international Commission, is the proper solution and is the most feasible manner in which the fishery of the Fraser can be restored and conserved. Such solution has been proposed and has been pending a number of years but meanwhile the fate of the fishery is in the balance. As Babcock[2] has long maintained "Canada throughout has stood for conservation. She has put forth earnest and conscientious efforts to conserve the supply and to prevent depletion. Her record is clear and unmistakable. She failed because she did not have jurisdiction over the entire system. She alone could not provide adequate protection but she did all that was possible under the circumstances."

It has been noted above that the pack obtained by the American interests in Puget Sound has at all times equalled and frequently exceeded that of Canadian canneries. Throughout, however, the full burden of ensuring the continuance of Sockeye runs, by means of artificial propagation, has fallen upon Canada. Hatcheries and egg-collecting stations are maintained at strategic points and every effort is made to counteract, by more effcient fertilization and hatch of eggs per fish, the reduction in total numbers of spawners through commercial fishing.

Propagation of fishes is claimed, in many instances, to be successful and to be a sufficient aid in the perpetuation of supply. In the case of the Sockeye, the peculiar habits and the vast extent of the spawning areas make the problem exceedingly difficult and complex. Figure 2 has been constructed to show the relation between the combined packs of Puget Sound and the Fraser River and the number of eggs handled in the Fraser in the preceding fourth years. No close agreement is observed. Variation in the packs from year to year has continued irrespective of the amount or extent of propagation and the very evident depletion in the latter years occurred with propagation at its height. It may be observed that propagation in the years 1901, 1905 and 1909, coincides with comparatively large packs in 1905, 1909, and 1913, but from examination of the graph it would appear that this agreement is due to the more favorable conditions for taking eggs in the

[2]Babcock, J. P., 1920. Canada and the United States can restore the Great Fraser River Fishery. Trans. Amer. Fish. Soc., 1920.

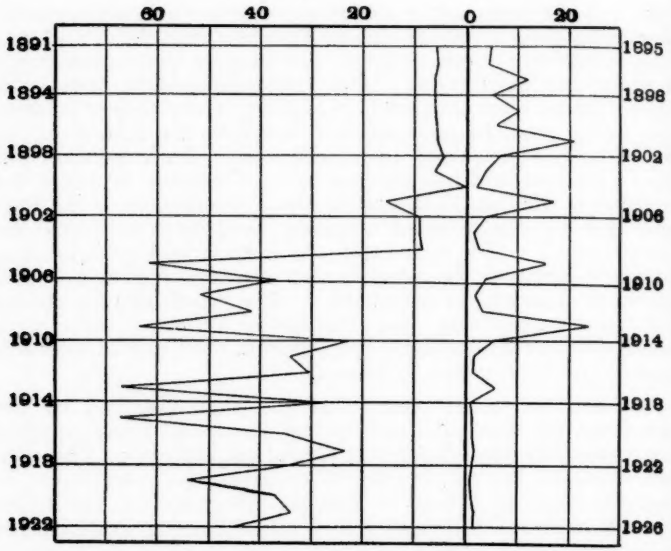



Figure 2. Graph showing the relation between numbers of eggs propagated artificially (left portion of graph) and the pack in cases for the Fraser River and Puget Sound combined in the succeeding fourth year (right portion). In the left portion of the graph, for eggs propagated, each horizontal space constitutes 10 million eggs; in the right portion, pack of Sockeye in cases, each horizontal space is equivalent to one million cases.

big years of 1901, 1905, and 1909, rather than that the packs of succeeding fourth years were caused by increased propagation. For example, it would appear more likely that the extensive collection of eggs in 1909 was due to the increased facilities for taking eggs from the large run of 1909 than that this collection and distribution resulted in the large run of 1913. In other words the two parts of the graph show the relation, not between propagation and resulting catch in the following fourth year, but between pack and resulting collection during the same year. This fact is more clearly displayed during the later years, 1915 to 1922, when a greater number of hatcheries and improved methods of collecting eggs resulted in comparatively extensive propagation but no effect of the increased propagation is reflected in the succeeding cycle years. As a matter of fact, the packs from 1920 to 1926 show

an inverse relationship, increasing in 1921 and 1925 with reduced propagation in 1917 and 1921.

In how far the inclusion of data relative to the propagation of Sockeye in American streams, whose fish enter into the pack of Puget Sound, would affect the graph cannot be estimated. These data were not at hand and could not be included but it is well known that propagation of Sockeye in the State of Washington has been carried on for a number of years on a fairly large scale. In any account, it would merely extend the limits of the graph of propagation and confirm the statements above made to the effect that the success of propagation is not reflected in the pack of the following cycle year.

It does not follow that the propagation of Sockeye is a failure but it is demonstrated that up to the present natural propagation has played the larger role and has been chiefly responsible for what runs exist. In other words, the runs to the Fraser have not yet dwindled to the point where natural propagation is inadequate in all areas and where the effect of artificial propagation is reflected in the annual packs. That artificial propagation is decidedly beneficial and necessary at certain times is abundantly proven but it is apparent that its purpose is not to improve or supplement natural propagation on a large scale but rather to be used in the building up of runs to ruined or seriously depleted spawning areas.

Thus far we have dealt with conditions and practices as they have been maintained in past years. Ward[3] has stated with regard to the Fraser River problem that "the conservation of such a resource rightly demands the careful consideration of scientific men while at the same time the striking life history of the Pacific salmon appeals most strongly to the scientific imagination as a biological problem of the highest interest." Of recent years this consideration by scientific men has become manifest and is illustrated in Canada by the work which the Biological Board of Canada has initiated particularly with regard to Sockeye salmon. The purport of the scientific investigation is not that of amending the old or establishing new regulations nor the taking over and manning of hatcheries but rather that of undertaking a critical and comprehensive study of the basic and fundamental factors controlling or bearing upon the life history of the Sockeye as well as a rigid test of the artificial methods of propagation in all their parts.

The chief merit held responsible for artificial propagation is the fact that successful fertilization and hatch of eggs per

[3]Ward, H. B., 1921. Some of the Factors Controlling the Migration and Spawning of the Alaska Red Salmon. Ecology, Vol. II, No. 4.

female is much greater than in nature. The chief argument against it is the fact, that, in comparison with the number of adult fish spawning naturally, those handled at egg-collecting stations appear infinitesimal, with the result that any gain through increased production in hatcheries is but, colloquially speaking, a drop in the bucket. The results of Figure 2 lend credence to this contention.

To firmly establish this point it was decided to make comparative tests of natural and artificial propagation, taking into consideration at the same time the two methods of artificial propagation, namely, development to free-swimming stage with liberation of fry, and rearing only to the eyed egg stage with planting of the latter in gravel beds of natural spawning areas. For this investigation a natural spawning area, situate on a small lake, tributary to the Fraser, open throughout the year, and readily accessible, was chosen—at Cultus Lake, B. C. The advantage of the small lake lay chiefly in the fact that its outlet could be completely screened and all arrivals to and escapement from could be readily enumerated. A program was arranged covering a period of twelve years whereby each of the three methods of propagation would be tested at least four times, sufficient, it seemed, to give allowance for natural variations caused through the influence of variable weather and water conditions.

The investigation commenced with the natural spawning of Sockeye in 1925, to be followed in 1926 with artificial propagation and distribution of free-swimming fry. In 1927 it was the intention to carry out artificial propagation with planting of eyed eggs but owing to the fact that 1927 was the year of a reputed "big" run to Cultus—indications of its probable extent were observed the previous fall—and since planting areas at Cultus Lake were limited, it was decided to alter the program by substituting for the second method of artificial propagation, natural spawning, the former to be carried out the following year, 1928.

The procedure consisted of the counting of all salmon reaching the weirs below the lake together with a determination of the sex, their release in years of natural propagation to spawn in the lake and tributary streams and their capture and spawning in years of artificial propagation. The results of the investigation to date are given in the accompanying table and show the number of spawners, the proportion of sexes and the number of eggs included in the run, estimated on the basis of 4500 eggs per female. Detailed scientific papers covering the results of this investigation are being

published in Contributions to Canadian Biology and Fisheries as Studies from the Canadian Biological Stations.

In the lower section of the table are given the results of the enumeration of down-stream migrants. These counts were made possible by the construction of a permanent screen fence, with traps, across the outlet stream of Cultus Lake, completely closing the outlet to down-stream migrants, including fry. The data for none of the spawnings are complete and are offered merely as an example of the methods being followed in the investigation.

In a practical problem of this type it is highly desirable that the losses occurring in each phase of the life-history be ascertained. Division of losses into two stages, fresh-water and marine, has been made possible by the count of seaward migrating fry and yearlings and constitutes an important advance over the former method of computing the success of propagation by returning adults only. Further division of the fresh-water phase into degree of mating per male, fertilization per female, and per cent hatch per female, in natural conditions seems impossible and may be ascertained only through experiment. Such experimental tests have been initiated at Cultus Lake but so far have not proven successful, due to the peculiar temperament, as it were, of the female Sockeye.

**Results from Sockeye Salmon Investigation at Cultus Lake, B. C.**

| Method of Propagation | Natural | Artificial | Natural |
|---|---|---|---|
| Year | 1925 | 1926 | 1927 |
| Males | 1,540 | 3,122 | 25,658 |
| Females | 3,883 | 1,949 | 55,569 |
| Total eggs | 17,473,500 | 8,770,500 | 250,060,500 |
| Total distribution | 17,473,500 | 5,916,524 | 250,060,500 |
| Per cent distribution | 100 | 67.5 | 100 |
| Year | 1926 | 1927 | 1928 |
| Seaward migrants, Fry | 12,568 | ..... | 116,977 |
| Per cent of distribution | 0.07 | ..... | 0.05 |
| Migrants, One year old | 183,272 | now being counted | ..... |
| Per cent of distribution | 1.05 | ..... | ..... |
| Migrants, two year old | now being counted | ..... | ..... |
| Total migration in per cent of collection | 1.12 | ..... | ..... |

Other factors having a bearing upon the developmental stages of the Sockeye are also being noted, particularly food

and enemies. The great divergence in numbers of naturally-spawning fish and consequently of eggs laid down in 1925 and 1927 is remarkable and great importance attaches to the difference in numbers of down-stream migrants. Particularly with regard to food will the result of the large spawning be of interest. Gilbert[4] has stated that "the question of available food-supply in the lakes becomes a pressing one in such a case, but has as yet received no attention. It should be thoroughly investigated, not only with reference to such great natural variations in the demand as shown in the present instance (reference being made to the big year runs) but also in consideration of conditions artificially caused, where eggs from an extensive watershed are concentrated in one hatchery and the fry are planted in a restricted area. In the case of the Fraser, it has seemed entirely possible that so extensive a brood as is provided during the big years might find itself limited in food to such an extent that the individuals would become emaciated and dwarfed during their year's residence in the lake. It has also seemed possible that an unusual proportion might be driven to migrate as fry as soon as the yolk-sac was absorbed." Regular plankton hauls are made throughout the year in association with physical and chemical determinations of the lake-water and direct comparison between the amount of plankton and the sockeye population from year to year can be drawn.

In addition, experimental work with regard to hatchery practices, oxygen requirements of eggs, alevins, and fry at various stages, limits, in point of time, of fertilization, are being carried out. More recently, attention has been directed to the practice in hatcheries of carrying away and burying carcasses of spawned Sockeye. There may be caused, thereby, severe loss to the lake in organic constituents. In natural spawning, the participants linger for a time about the spawning beds and eventually die. Their bodies sink to the bottom and decomposition sets in, adding to the area a large mass of organic detritus. The loss of the potential organic matter in several thousand Sockeye bodies may reduce in large amount the natural components of the food-chain and may bring about, under artificial propagation, a reduced food-balance for the reared and introduced fry which would be sufficient under normal conditions for the same number of fry.

In other words, propagation in every phase and from every angle is being investigated with a view, on the one hand, to

[4]Gilbert, C. H. 1913. Contributions to the Life History of the Sockeye Salmon. Paper No. 1. Report of the B. C. Commissioner of Fisheries, Victoria.

obtaining a full realization of the relative efficiencies, and, on the other, to examining the present system and devising improvements.

At the same time the opportunity is presented of studying in detail a single, well-marked race of Sockeye on its native spawning grounds. A great body of data has been collected regarding the Sockeye salmon, length, weight, age, etc., and variations thereof from year to year, but this information covers a composite mass of individuals representing the many and varying spawning areas of the entire Fraser. No knowledge is available which defines the variation or regularity in character of the runs to a definite spawning bed. In order to obtain such, material must be secured after final segregation has occurred and at Cultus Lake such segregation has taken place. The components of each year's run are examined as to length, weight, age, rate of growth, and proportion of sexes and thereby a mass of information is being accumulated which should trace with sufficient accuracy the trend of natural conditions on a spawning area over a period of time, throwing light upon many of the natural phenomena of the past of which the story of the Sockeye salmon is replete.

The determination of the relative efficiencies of the various methods of propagation is but one step in the solution of the Fraser River situation. We are faced with the problem of an immense river system suffering severe depletion throughout and probable virtual extinction in certain areas. It is well known that the major runs of Sockeye in the Fraser, and these comprising the largest and most valuable fish, were bred in and returned to the upper sections of the river, that is above Hells Gate Canyon; further, that of recent years the fishery has been more or less maintained by Sockeye from the spawning areas of the lower Fraser, generally considered an inferior type. Recovery of the fishery therefore involves the restoration of Sockeye to the upper river spawning grounds. Two avenues of approach are available:

(1) Restoration by returning spawning adults.

(2) Repopulation through transfer of artificially-reared eggs or fry from well-seeded areas.

Both methods have been adopted in the past. On the one hand weekly closed seasons have been provided for the escape of adults to the spawning beds, and, on the other, eyed eggs have been transferred from the lower to upper river areas. That the former method has been, in a measure, successful is shown by the fact that certain runs to the lower spawning grounds have been maintained and that, as demonstrated by

Figure 2, the annual pack has, of late years, oscillated about a low level. That the practice of transferring eggs from one area to another has been satisfactory is open to question. Within the last few years an extremely late run of Sockeye has developed, which, it is claimed, has resulted from egg planting. As far as numbers of fish are concerned, some success has been thus attained, but when there is taken into account the fact that these fish are of inferior quality, failing to produce a high-grade product, and that they arrive on the spawning grounds very late in the year, at a time when successful propagation is extremely improbable, judgment must be reversed. Restoration of the Fraser cannot be brought about by temporary replacement by an inferior type of Sockeye. Such is but a hand-to-mouth existence.

Yet both methods are, in principle, sound and restoration can be brought about only through their adoption and proper application.

The spawning areas of the Fraser may be divided, roughly, into three classes, according to their condition:—

(1). Depleted but with a sufficient spawning element to ensure perpetuation.

(2). Severely depleted—possessing only a few native spawners.

(3). Completely barren—native spawners extinct or very rare.

In approaching the situation the following preliminary surveys must be completed:—

(1). The determination of the operating and probable spawning beds of the Fraser.

(2). The class or condition of each spawning area.

(3). The typical characteristics of each area—

(a). When the spawners reach the fishing limits.

(b). When the spawners reach the spawning grounds.

The most feasible means of obtaining the necessary information regarding the individual spawning areas of the Fraser is through an extensive tagging program carried out in the fishing areas, followed by a careful survey of the spawning grounds for recovery of tags. In this way, definite information will be obtained as to when the fish bound for each spawning area reach the Fraser. And with this knowledge at hand

progress may be made in the restoration of those spawning areas of the first class—that is, those possessing some degree of natural spawning—by mere increase in numbers of spawners through the operation of a closed season at the time when the fish from these areas approach the fishing limits. Proper seeding of such areas is purely a matter of regulation, based on scientific knowledge.

With regard to the other classes of spawning grounds, two in number, and exhibiting severe depletion or practical extinction, the problem is, without question, more complex and involves more careful study and greater perseverence. Many of the spawning areas of the upper Fraser would seem to fall into these classes. Runs to them have ceased or the returning adults are so few that they, of themselves, are unable to suitably reseed the area. In such cases reliance must be placed upon artificial propagation. But not the haphazard distribution of eggs of the past, from here to there and there to here, but rather one of rigid selection.

Gilbert in his extended and excellent researches into the life-history of the Fraser River Sockeye has postulated that each tributary of the Fraser system possesses its own race of Sockeye, distinct in physical characters and habits and that this rigid distinction of definite types therefore belies any theory of intermingling which may be raised. There arose, therefore, the belief that the Sockeye invariably return to the area in which they are reared, a theory which is at the basis of Sockeye propagation on the Fraser today. However accurate the theory may be under normal conditions it is anticipating a great deal to expect it to remain true under the very unnatural conditions of egg transference. For example, eggs from Cultus Lake Sockeye were transferred to and planted in Eagle River of the Shuswap area in 1922. While Cultus Lake Sockeye may and do normally return to Cultus Lake, it does not follow that the planting in Eagle River will result in a run to that area. When the conditions to which the fish in question must accustom themselves are considered, it is seen that virtually a miracle is asked of these individuals. In the first place, Cultus Lake Sockeye are deemed an inferior type, poor in oil and small in size. In the second place they enter the Fraser during late September and October and spawn shortly after reaching the lake. Third, they are forced to travel upstream a distance of only about seventy-five miles. Yet they are expected to increase their oil content and their strength sufficiently to proceed upstream, through extremely difficult channels, an added 300 miles at least and moreover,

are supposed to reach their adopted spawning beds as soon as, if not earlier than, they would otherwise reach Cultus Lake.

It is probably true that the transplanting would result in the returning adults passing upstream enroute to Eagle River but it is not yet known how far they are able to travel. Under the circumstances, it seems most probable that the migrants fall by the wayside, far short of their destination. The spirit of the Parent-Stream theory is willing but the flesh is weak.

Reference has been made to the late-fall runs which have occurred in recent years and which are reputed to have resulted from egg planting. Should such be true it is very evident that transference from one area to an earlier one does not lead to an earlier return from the sea. In this event, even though the spawners did reach their spawning beds, they would be too late to provide successful seeding due to low water and low temperatures. And, in falling by the way, the chances of spawning fish finding suitable spawning ground are exceedingly slight. Great concern has been felt, of late, over the alleged losses at Hells Gate Canyon, where spawning Sockeye, presumably unable to stem the churning current, drift back, exhausted and die unspawned. It is just possible that these exhausted migrants are the product of lower Fraser fish, transplanted to upper river waters, wearing themselves out in an effort to reach their adopted spawning grounds but unable physically to proceed thereto. It is seldom that Coho or Spring salmon are reported as constituting a part of what is termed the Hells Gate Slaughter. These varieties reach their native haunts in perfect condition, as do some races of Sockeye. If conditions in the canyon were uniform and wholly responsible, all types making the passage should suffer equally. It is reported that Sockeye have been taken from the waters below the Gate in dead-ripe condition but it may be postulated that any Sockeye, native to the waters above and travelling thereto, should not be found in such condition at that stage of its journey.

Such is the troublesome problem which looms so largely in propagational work on the upper Fraser. A beginning has been made in the determination of the return from lower Fraser eggs when planted in upper Fraser waters—at Eagle River—but owing to the unfavorable water conditions in the area and the expense involved in maintaining adequate structures, progress has been slow. A count was made at Eagle River in 1926 to determine the return of adults from a planting of 3,000,000 eyed Cultus Lake eggs made in 1922. Four only were recovered. The counting weir was washed out on two

occasions and replaced but a careful survey above the weir failed to disclose any escaped individuals. At any rate it was clearly proven (confirmed the following season) that the plantings in Eagle River failed to establish runs to that spawning area. Whether the planting was successful in point of seaward migrants was not known and no means was available to trace their route on return from the sea but as far as Eagle River restoration is concerned, no satisfactory results were achieved. The area remained as barren as before plantings occurred. Following up this work an attempt is being made to establish an experimental planting area on Eagle River at which different races may be planted, the resultant fry marked in order that they may be identified on return to the Fraser and the number returning to Eagle River ascertained. The races experimented with should include:

(1). A lower Fraser race, to trace their return, whether to Hells Gate or above.

(2). A native race—if such is available.

(3). A race from the upper waters of the Skeena or other river, to determine whether they are physically able to make the complete return journey.

In this way only can definite knowledge be obtained as to the causes for success or failure of the different races introduced and, with such in hand, a systematic plan of artificial propagation and restoration be initiated with hope of any measure of success.

In the case of that class of spawning bed which has suffered serious depletion but where some remnant of the native run remains, conditions may be satisfactory for the capture and spawning of such survivors as return and the deposition of the product in the most efficient manner, thus enabling a native race to be built up without much trouble. Where, as in the third class of spawning ground, the beds are barren of Sockeye, rigid selection of planting material must be made in order to ensure proper return.

If it be deemed sufficient merely that large numbers of Sockeye be returned to the fishing limits each year, such can be achieved readily by mass propagation of eggs from the lower Fraser at any convenient point year by year. Such, however, would not be restoration. An honest attempt must be made to rebuild runs, which, with sane regulations, will perpetuate the race. To do so they must possess the essentially desirable qualities of former native runs, namely, large size, high quality, and early spawning.

In recapitulation, it may be stated that while the Fraser has suffered severe depletion in the past, it has been through measures which can be remedied in the future. The prospect of restoration is not then hopeless.

The first essential is an extensive tagging program on the fishing grounds to catalogue the time of arrival and the destination of the several races passing up the Fraser in conjunction with a thorough survey of the spawning areas to locate the returning tagged migrants.

From this will follow a classification of the many spawning grounds into three classes, those possessing a sufficient run to allow for natural seeding; those suffering severe depletion but with a remnant of the native run; those completely barren.

In the first class, restoration may be brought about by closed season at the time the fish from these areas pass the fishing limits.

In the second, propagation of the survivors of the native races on the ground or on adjoining beds by the most approved methods of artificial propagation will result in the recovery of these races.

In the third, essentially rebuilding of runs must be made. Haphazard planting of alien eggs will not avail and only by rigid selection of the proper type of Sockeye can desirable runs be restored.

A beginning on scientific lines has commenced. Preliminary tagging operations on the Fraser are under way. An extensive investigation of the relative merits of the various methods of propagation, natural and artificial, is being carried out, to proportion losses under their proper heads, together with a thorough study of a native race, after segregation, on its natural spawning ground. And lastly, plans are being formulated for an investigation leading to the discovery of the best type of Sockeye adaptable for transplantation to the barren or destitute spawning areas of the upper Fraser.

It was once remarked by Babcock that "the spawning area of the Fraser requires no expenditure of money to bring it into bearing. If permitted to reach the beds in sufficient numbers, the fish will seed them, the young will feed themselves, and furnish their own transportation to and from their feeding grounds in the open sea. If permitted to do so, the fish will do all the work necessary to produce a catch worth thirty million dollars a year. All that is necessary is for the Governments of Canada and the United States to adopt measures which will afford a free passage through their waters to a sufficient number of sockeyes to seed the spawning beds. The run

of sockeyes to the Fraser River system cannot be restored in any other way."

Natural propagation may at one time have proven sufficient to fulfill this purpose but time has flown. A combination of natural and artificial propagation must now be advanced. At that, with thirty million dollars at stake, the odds are on the right side.

In other words, an international treaty binding the whole area served by the Fraser into one is essential, not necessarily to make possible a four or five year "closed" season, but to allow for uniform regulation throughout the whole fishing area. If such a treaty cannot be arranged, Canada must tackle the problem alone and in such a case she cannot be held culpable if means are taken to propagate on the Fraser those races of Sockeye now native to the north-western coast of the mainland, which enter the Straits from the northern end of Vancouver Island and thus escape American traps and nets.

The restoration of the Fraser is but a matter of time if a start is made at once but with conditions left as they are, there is greater danger than that due to over-fishing. Already there is being felt the encroaching influence of the water-power, the irrigation, and the lumbering interests. While the Fraser supports an adequate fishery, that fishery holds sway, but as the power of the fishing industry grows weaker, that of inimical interests waxes, and the time is approaching, when, if the fishing industry does not act, the competitive concerns will demand and receive such strategical points as they desire, which will spell the doom of the famous Sockeye fishery of the Fraser River.

*Discussion.*

MR. BABCOCK: I want to express my appreciation, having studied the conditions on the Fraser River for twenty-seven years, of Mr. Foerster's addition to the literature on this subject. It is most interesting and most valuable, and Mr. Foerster is one of the men to whom we look for the solving of that problem in the future.

## INTERNATIONAL PACIFIC SALMON INVESTIGATION FEDERATION

By Charles R. Pollock

*Supervisor State Fisheries, Seattle, Washington.*

One of the outstanding developments in fisheries conservation work during the past biennium was the movement started early in 1925 when the fisheries officials of Canada and the United States met in joint session with those of Alaska, California, Oregon and Washington and formed the "International Pacific Salmon Investigation Federation," the first meeting being held in Seattle with the State Fisheries Board of Washington on March 16 and 17, 1925.

The second meeting of this body was held in the office of the U. S. Bureau of Fisheries, Seattle, on November 24, 1925, with Hon. Henry O'Malley, United Statees Commissioner of Fisheries, presiding. Reports from all the districts were made on tagging experiments and other investigations conducted during the summer of 1925 according to the preliminary plans formulated at the previous March session. Space does not permit a detailed discussion of the various reports, but the results of this cooperative effort between the fisheries officials of the Pacific Coast States and the national fisheries officials of both Canada and the United States show that work of this character is greatly needed and is in the right direction.

On December 2, 1926, the third meeting of the Federation took place in Seattle at the office of the United States Bureau of Fisheries. Mr. O'Malley again presided and all the coastal states, as well as Canada, British Columbia and Alaska were represented. The chairman of the program committee, Dr. Willis H. Rich, presented an outline based upon field experience and upon suggestions made at the previous meetings. After a full discussion of the various subjects, the meeting adjourned, subject to the call of the chairman. It was suggested that the various sub-committees continue their study of the various phases of the work outlined below and be prepared to make reports at a later meeting.

### "REPORT OF THE SUBCOMMITTEE ON PROGRAM OF THE EXECUTIVE COMMITTIEE, INTERNATIONAL PACIFIC SALMON INVESTIGATION FEDERATION."

Dr. Willis H. Rich,

*Director of U. S. Bureau of Fisheries Laboratory, Seattle.*

The subcommittee wishes first to express its belief that the primary purpose of any program of research should be to produce the essential knowledge needed for proper and scientific administration of the salmon

fisheries. Our desire is to conserve effectively the great salmon resources of the north Pacific, and our conception of such conservation involves the utilization of the resources to the fullest extent compatible with their perpetuation. We would like to be able to say definitely how many salmon it would be possible to take from a given region and still leave sufficient for spawning purposes so that the supply will continue year after year at a high level. It has been repeatedy brought out at both of the previous meetings of this committee that the central idea about which we should build our program is the production of the maximum yield obtainable from this fishery, and by the maximum yield is meant the greatest production of fish which may be taken for commercial purposes without affecting the future supply. To provide adequately for this we must know: (1) what natural fluctuations in the abundance of salmon occur: (2) the causes of these fluctuations particularly the immediate causes through the ultimate causes should finally be known: (3) the intensity with which the commercial fishery is conducted and its effect on the future supply; and (4) the relative value of various measures which may be used to prevent depletion and to build up runs already depleted. With these fundamental requirements in mind the following program is presented:

1. Collection of adequate and uniform statistics.
2. Tagging experiments.
3. Scale analysis of the adult runs.
4. Study of the adult returns from known escapements to the spawning grounds.
5. Stream surveys of the spawning grounds.
6. Study of the production of seaward migrants from known escapements of the parent fish.
7. Efficiency of various methods of artificial propagation as compared with natural propagation.
8. Effect of transplantation.
9. Improvement of spawning areas and overcoming obstacles, natural and artificial. to the ascent of spawning salmon and the descent of the seaward migrants.
10. The life history in fresh water with particular attention to the factors affecting survival during this period of the salmon's life.
11. Life history in the ocean.
12. Study of the effect of sea fishing.

*Discussion.*

MR. CHARLES R. POLLOCK: Tagging experiments have been carried on by the British Columbia government and the Dominion government under the direction of Dr. Clemens and by the United States Bureau of Fisheries under Dr. Rich. The California Commission has been making some studies, and the Oregon Commission has been marking fish off the mouth of the Columbia River during the past two years. During the last two years my own state, Washington, has carried on tagging operations off Cape Flattery. Previous to 1925 we employed a purse seine with rather poor results. The past year we have been marking with tags the young fish which we have found in the various traps around Puget Sound. It is a little early yet for complete reports on these operations, which will be submitted at the next meeting of the association.

The commercial fishermen of the State of Washington pay all the expenses of commercial fishery work; not one cent of general taxation is used. In 1921 a new administrative code was put into effect in the State of Washington. Prior to that time the Department of Fisheries and Game was conducted under one head. Now the Department of of Game and Game Fish operates under funds received from the county game and state game licenses, and the Division of Fisheries receives its funds as previously mentioned. Although we are operating together the work is entirely separate. The game department, wherever it has hatchery facilities, takes salmon eggs, and the Division of Fisheries whenever possible takes steel-head trout eggs for the game department. As a result both receive the benefit of a smaller operative cost than if each department had to maintain entirely separate groups of hatcheries.

The Governor appoints a Fisheries Board of three persons which has the power to say when, where, and by what means fish may be taken within state waters. The legislature, however, still determines the license fee, what the taxes collected shall be, and deals with matters pertaining to the administration of the fisheries office. Our office is the administrative department under the Fisheries Board, the Fisheries Board acting merely as advisors in the expenditure of the funds, in making up the budget, and in providing for improvements and investigations.

In the short time from 1921 until this date our Fisheries Board has had marked success. Our salmon fisheries have not been depleted, although our catch of salmon has greatly increased since 1921, particularly in the odd-numbered years in Puget Sound, which is our largest fishing area, when our humpback salmon run and the larger runs of the sockeye take place. By regulation of the Fisheries Board the season has been reduced approximately one-third and all the streams in Puget Sound except two have been closed by gill nets or set nets, and the minimum limit of commercial fish has been increased from 14 to 18 inches.

DR. FOERESTER: Mr. Pollock has said that the salmon fisheries of this state have not been depleted. I would like to ask him whether the fishing industry of the State of Washington does not consider that the sockeye salmon fishery in Puget Sound has not been depleted, and if so, whether any measures have been taken to counteract this depletion.

MR. POLLOCK: My remarks referred to all species of salmon in general. The run of sockeye salmon shows considerable yearly variation. Last year our pack in Puget Sound was double the pack of the four years previous, and yet during the closed period of ten days in September great quantities of sockeye salmon passed to the spawning grounds. I would not want to make the statement that the sockeye have increased, but I think I am safe in saying that the situation is more favorable than it was prior to the time that stringent regulations were in force. Our Board has been looking forward towards some form of treaty with Canada on this proposition.

# THE TROUT OF BRITISH COLUMBIA

J. R. DYMOND.

*University of Toronto.*

The trout of the genus *Salmo* in British Columbia belong to three species,—steelhead (*Salmo gairdneri*), Kamloops trout (*Salmo kamloops*), and cut-throat trout (*Salmo clarkii*).

STEELHEAD. While the steelhead is not usually called a trout because in many cases most of its life is spent in the sea, nevertheless it spawns in fresh water and in some localities makes more or less regular migrations into fresh water at other seasons. In the sea it is bright silvery and shows comparatively few spots but in fresh water it gradually becomes greenish in colour above and develops more and larger spots and a reddish band along the side,—more pronounced and of a deeper colour under certain conditions. As is the case with remains in fresh water for some time before migrating to several years and some may never enter salt water being permanent residents of fresh water. In British Columbia the steelhead is largely confined to area 1 as indicated on the accompanying map. A few may ascend the Fraser beyond Hell's Gate but the difficult ascent at this point is believed to bar most of them.

KAMLOOPS TROUT. Over an enormous area in the interior of British Columbia (area 2 on the map) occurs a fresh-water trout to which Jordan has given the name of *Salmo kamloops*. In the larger lakes such as Kootenay and Okanagan this species reaches a very large size. Specimens over twenty-five pounds in weight have been taken on the troll and hatchery officials at Gerrard have spawned specimens which they estimate would weigh forty pounds. These large lake trout are bright silvery in colour except at spawning time and for a period before and after spawning when they show the red lateral band. Young specimens in the lake have a pink tinge along the side and are accordingly often called rainbows. In beauty and game qualities they are unsurpassed by any fish anywhere. When hooked they break water and leap repeatedly. Specimens up to five pounds in weight readily take the fly while larger ones are usually taken on the troll.

Jordan believed the Kamloops trout to be a land-locked steelhead but such is not the case. The two species are no doubt derived from a common ancestor at some distant time but the Kamloops trout is a true fresh-water species. The

fact that it reaches a great deal larger size than the steelhead indicates that it is not a land-locked race of that species, for land-locked forms of marine species are dwarfed as compared with the marine forms. There are in addition a number of structural differences which indicate that the two species are totally distinct. They are, however, much more closely related than either of them is to the cut-throat.

CUT-THROAT TROUT. The cut-throat gets its name from a red coloration on the under side of the lower jaw. It also has teeth on the back of the tongue in addition to the teeth farther forward which all trout possess. As compared with the steelhead and Kamloops trout, the snout of the cut-throat is more pointed, the head longer and the body more rounded. The red throat gash and hyoid teeth are both variable characters. The red under the lower jaw varies from a deep red coloration covering the entire area to a small pinkish spot and in some cases, notably in salt water, to the absence of any trace of red. Similarly the teeth on the back of the tongue vary from a definite series of strong teeth to a few weak teeth and in some cases to the entire lack of such teeth. Cut-throats have a peculiar distribution in British Columbia. They are very common in coastal waters (area 1 of the map) but are practically absent from the great area in the interior occupied by the Kamloops trout. In this region so far as our survey to date indicates, they are confined to a few isolated localities indicated by circles on the map. We know that their occurrence in some of these localities is due to fish cultural operations but the cut-throat is probably native to a few of the streams in this area. In any case the form found here differs markedly from those found elsewhere in the province. In area 3 which comprises the headwaters of the Kootenay river and the southern Canadian Rockies the cut-throat appears to be the only native trout. The limits of this area are not yet well known. It is of interest to note further in connection with the distribtuion of the cut-throat trout that in area 1 the cut-throat is the dominant fish of the lakes whereas in the interior (area 2) the Kamloops occupies all the lakes and the only cut-throats which occur occupy a few small streams. At the coast cut-throats are often found in salt water and some so-called steelheads are really cut-throats.

As a game fish the cut-throat in British Columbia is not so highly regarded as the Kamloops.

RAINBOW TROUT. The term rainbow trout is often applied in British Columbia to black-spotted trout having a red lateral

band. In this way the term is used for various forms of the Kamloops trout and for the steelheads when taken in fresh water. Whether this is a legitimate use of the name rainbow or not is an interesting question. Jordan says that he invented the name rainbow trout in 1878 for the trout of San Leandro Creek near Alameda, California to which Gibbons in 1854 had given the name *Salmo iridia*, the term rainbow being a translation of the Latin name of the species. If that is the only trout to which the name rainbow may properly be applied, I doubt whether we have any right to use the name for any of our native British Columbia trout. The name is in such general use throughout America to designate black-spotted trout which develop the red lateral band that I think it is impossible now, ever to restrict it to the form for which it was originally invented. It is important, however, to have it understood that the term is a very general one and includes at least two species and many geographical and ecological races of these.

SIZE, RATE OF GROWTH AND COLORATION. It is generally known that fish of the same species reach widely different sizes in different waters. A species which grows to a weight of many pounds in some waters will never reach a weight of more than a few ounces in others. The rate of growth of a species will therefore differ very greatly depending on the conditions. In British Columbia trout have been introduced into a number of so-called barren lakes, i. e. lakes from which fish have previously been absent. In most of these the trout make a phenomenal growth,— two or three times as rapid as that made in the best of the lakes in which they occur naturally. This very rapid initial growth is undoubtedly due to the abundance of food. Later when the trout have eaten the superabundance of food, the rate of growth falls very seriously.

Similarly the colour of trout varies considerably with the conditions in which the fish are found. In some of the large inland lakes, as already pointed out, the trout are bright silvery, whereas in streams and small lakes the same species has a dark green back, a red side and is quite heavily spotted. There is a limit beyond which an individual fish cannot go in changing its colour or its pattern but there is a surprising range of variations in colour and markings within these limits.

RACIAL DIFFERENCES. It is hardly necessary to say that there are great differences between the Kamloops trout in

widely separated regions of the great area over which they are found. There are also striking differences between the trout of neighboring waters in which conditions are very unlike, as for instance a large lake at a low altitude, a small mountain lake and a swiftly flowing river. Some of the differences exhibited under these circumstances are no doubt due directly to the environment and an individual fish taken from one of these habitats and placed in another would take on some of the characteristics which distinguish the trout of the latter, but some of the differences are of a more permanent nature. There is no information, however that will enable us to estimate the relative effects of heredity and environment on the size and other characteristics of a trout. What effect transferring the small, brightly-coloured trout found in mountain lakes to a large lake in which the native trout are large and silvery is something which can only be determined by experiment. In this connection it is of interest to mention that brown trout taken from Dorsetshire in England to New Zealand quickly ran to sea and became large silvery fish.

While, therefore, some of the characteristics which distinguish the trout of certain bodies of water as compared with others, are subject to change when the environment is changed, there are others which are evidently fixed hereditarily. Thus the native Kamloops trout of each body of water and of each area have characteristics which distinguish them from those of other regions, but there appears to be perfect gradation between the most extreme of these forms so that it is a matter of individual taste as to how many races may be recognized.

In the same way there is wide difference between the steelheads of different localities along the British Columbia coast. These differences have been largely overlooked because, popularly at least, only individuals that have been in salt water are recognized as steelheads and their life in the sea has produced a striking uniformity in their appearance. But even if we confine our observations to steelheads from salt water we find surprising differences in scale counts and body proportions between lots from different localities along the coast. There is no doubt also, a considerable difference among steelheads in their preference for a salt or fresh-water life. Whether there is in the coastal streams a strictly fresh-water species of trout, distinct from the cut-throat and the steelhead is a question on which not only have different ichthyologists held different opinions but the same ichthyologist has held different opinions at different times. When we begun our study of

these trout it appeared as if our results would correspond with Gilbert's about Astoria near the mouth of the Columbia where, according to Jordan and Evermann, he found *Salmo mykiss* (*clarkii*) and *Salmo gairdneri* occuring together and perfectly distinct and both easily and unquestionably distinguished from a third form (*masoni*) found in the brooks of the same region and not descending to the sea. However as our collection has grown, it has become increasingly difficult to recognize in the coastal streams more than two very variable species viz., the cut-throat and the steelhead.

PRACTICAL SUGGESTIONS. I believe that the differences which characterize the races of trout which nature has selected for particular conditions should be taken account of in the work of artificial propagation. So far as possible we should propagate for a particular body of water the trout native to it, provided of course that temperature and other conditions have not been so changed as to make it unsuitable to the native species. We should at least aim to plant waters with trout from as nearly as possible the same locality and similar ecological conditions.

It is a mistake too, I believe to plant Kamloops trout in cut-throat waters or cut-throat trout in Kamloops waters. In British Columbia they are practically never found together naturally.

I am also of the opinion that it is the duty of all who are interested in the conservation of our western trout to resist the demand for the introduction of exotic species of game fish such as black bass, eastern speckled trout and brown trout into our waters. There are possibly waters in British Columbia where it would be advantageous to introduce some of these species but such introductions should be made only after careful study of all the factors involved. There are no finer game fish to be found anywhere in the world than the trout we have right here and if any body of water does not produce satisfactory trout fishing it is more likely to be due to some deficiency in the waters rather than to shortcomings of the trout.

There is I fear, a growing demand on the part of anglers and the general public for the introduction of non-indigenous species of game fish but it is my belief that this demand is based on mistaken premises.

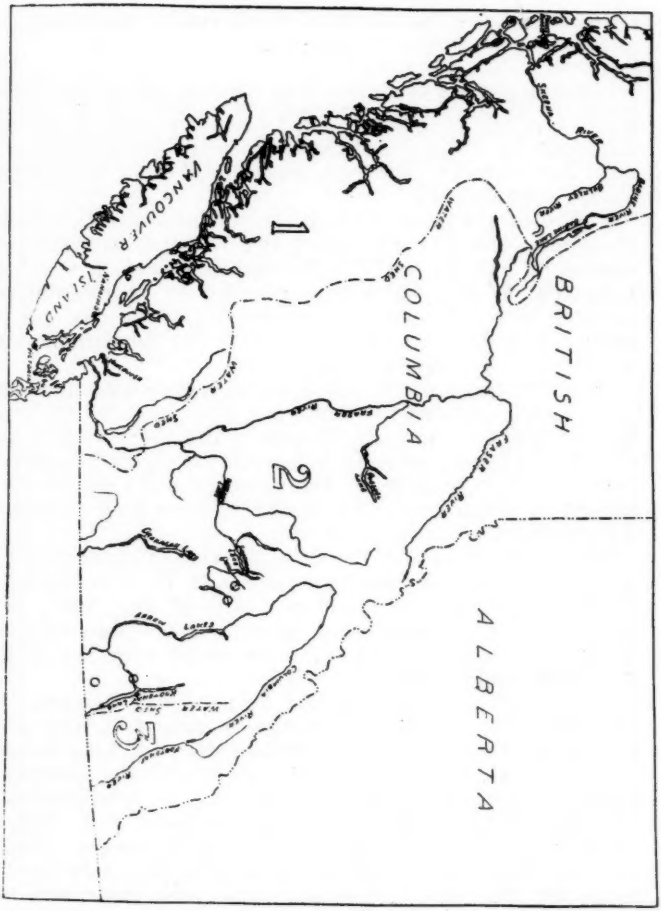
*Discussion*

MR. N. B. SCOFIELD (*California*): Do you find that any of the cut-throat trout run to the sea?

PROFESSOR DYMOND: Yes, the cut-throat trout are fairly common in the sea.

MR. N. B. SCOFIELD: I understood you to say that the steelhead was the only one that ran to sea.

PROFESSOR DYMOND: In coastal waters we find it difficult to distinguish more than two very variable species, the cut-throat and the steelhead.




Map showing areas of distribution of trout in British Columbia. Area 1 contains steelhead and the cut-throat trout; area 2, Kamloops trout generally distributed, cut-throat trout in areas indicated by small circles; area 3 cut-throat, the only native trout.

# THE WORK OF THE WESTERN FOOD AND GAME FISH PROTECTIVE ASSOCIATION

By Harold Synnestvedt.

*Chairman, Western Food and Game Fish Protective Assiciation, Kalama, Washington.*

For many years there has been a heavy toll of fish life taken annually in the various irrigating developments of this country. Attention has been called to this matter on numerous occasions by Federal and State Conservation agencies. Not until last October, however, was anything of a constructive nature accomplished.

Following the publication of the resolutions of the Washington State Game Commissioners and Wardens at their October session in Yakima, early in November a meeting was held in Longview, Wash., which was attended by representatives of commercial fish interests, sportsmen's associations, game and game fish authorities, and members of the fish commissions of both Oregon and Washington.

In a discussion of the life cycle of the various anadromous fishes, it was pointed out that while numerous fish ladders had been installed in the main streams of the Northwest, to enable the adult salmon and trout to ascend the rivers to reach their spawning beds, it was of little avail, for the reason that no protection was afforded the small fry, when they wended their way seaward as downstream migrants.

At certain seasons of the year, the large Government diversion canals, such as the Sunnyside and Wapato canals, took considerable in excess of 90 per cent of the water of the Yakima River. Naturally, along with this water, millions of small fry salmon and trout, were swept over the irrigated land, eventually to die.

It was evident that it would be necessary to screen these main diversion canals, and provide by-passes in order for the downstream migrants eventually to return safely to the parent streams. To foster this project as vital to the sportsmen as it was to the commercial fish interests, an organization was formed, called the Western Food & Game Fish Protective Association, with committees apointed in Oregon, Washington and Montana, including in membership both food and game fish interests. The association was instructed to endeavor to procure from Congress legislation and appropriation, and to determine the correct type of fish-screen to be used. Senator Jones of Washington introduced a bill in the Senate,

and Representative Albert Johnson introduced a companion measure in the House of Representatives. The Association sent an emissary to Washington, D. C., to properly present the subject before the proper Committees of the House and Senate. Finally a Bill passed Congress and was signed by President Coolidge, authorizing the Department of Commerce, through its Bureau of Fisheries, to investigate the fish screen problem, appropriating $25,000.00 for that purpose.

With his usual promptitude, Secretary Hoover, through Fish Commissioner, Mr. O'Malley, immediately appointed Mr. Shirley Baker, an eminent enginneer of San Francisco, California, to take charge of the field work. Mr. Baker and his able assistant Mr. U. B. Gilroy, have traveled over the Northwest, have investigated the numerous types of screens in operation, and while their report has not yet been filed, it is understood that they are satisfied that a screen competent to protect the fish, and at the same time, not block the flow of water can be developed.

Within the space of nine months, absolutely new legislation has passed both houses of Congress, an appropriation has been secured, and government agencies put to work in the field. An early solution of a vexing problem of twenty years standing is practically in sight. This achievement could not have been accomplished except by bringing together under one association, all the various elements interested in the matter, and by united effort on the part of officials, packers, fishermen, farmers and sportsmen.

## FISH SCREENS IN IRRIGATING DITCHES

By Shirley Baker

*Consulting Engineer, U. S. Bureau of Fisheries*

Since no definite conclusions have as yet been reached in our investigation of fish screens, there is little to be reported. However, a brief resume of our work to date may not prove uninteresting. As most of you know, I have been appointed by the U. S. Bureau of Fisheries, "to study, investigate and determine the best means and methods of preventing the destruction of fish occasioned by ditches, canals and other works constructed or maintained by the United States."

It has seemed wise, as the first step in our study, to make a thorough survey of the work already done along this line by the Government, State, or other authorities. Already my assistant, Mr. U. B. Gilroy and I have covered considerable territory in Oregon, Washington, and Montana. California and other nearby states where the existence of efficient devices warrant are yet to be covered. We have examined several different types of screens—some efficient, some fairly satisfactory and others useless. Through the cooperation of the inventor and the State Game Commission of Oregon we have been instrumental in installing an experimental electric fish stop at the hatchery at Delph Creek, Oregon, which seems to have considerable merit. I take the liberty of reading from an article which appeared in the editorial section of the Portland Oregonian of Sunday, August 26 anent this installation—

"Tests of an electric fish screen, recently made at the Delph creek hatchery by the state game commission, are said to indicate that this method of controlling migration, and saving innumerable fish from destruction, is eminently practicable. The trout, even the most minor fry, were not injured by the current received, but in all instances were turned aside. If this method of control works as well in actual everyday use, as there is little doubt it will, one of the most perennial fish problems shall have been solved.

When to adequate fish screen are added adequate fishways, for which the sportsman and conservationist may venture also to hope, we may be reasonably sure of an improvement in fishing, and quite as certain of the future of our streams. The fishway that is no true way, but rather a barrier, and the fish screen that does not function, but permits the fish to be carried onward to their deaths, have

wasted the equivalent production of many hatcheries each year.

There is the economic loss to consider first, of course, for such is our custom. But there is a spiritual shame, as well. The unregarded, casual waste of any natural resource is a standing reproach to the people who permit it. They do not deserve, one is almost constrained to say, to dwell in a country on which providence has smiled."

The solution of this problem is not simple, as you, who have worked on it will agree, but our work to date encourages us to believe we shall be able to reach helpful and constructive conclusions.

*Discussion.*

MR. J. W. TITCOMB (Connecticut): I wish to inquire if anyone here has seen the screen operated by electricity.

MR. BAKER: We have one screen which is electrically operated, but it is a new installation and I have not yet seen it. I should prefer to examine it before I have anything definite to say concerning it. I have read a number of newspapers which speak very highly of it.

PROFESSOR JOHN N. COBB (Washington): I am very glad to learn from Mr. Baker that the Federal Government is investigating this problem. I regret that only engineers and no biologists are making these investigations. In this connection I might recall a little of the history of the electric fish stop. A young man came from Berkeley, California, with a seductive idea, which was patented, namely to divert fish by running an electric screen across a river. The state of Washington provided an electrical engineer for the purpose of testing the device. Unfortunately, he worked out the screen from an engineering standpoint, without regard to the fish. From my observation of several electric screens I have come to the conclusion that it is a fine engineering scheme, but it will not work with fish. The stops were located in ditches nearly a thousand or more feet from the river, a distance which is too great for the fish to get back to the main river. If the screen is put right across the mouth of the ditch where it is diverted from the main river, there is a possibility that you might keep them out.

In experiments at the University of Washington we were successful in stopping the fish, but unfortunately we killed them. Of five species of salmon, we found that the humpback could stand the most punishment. The fish merely received the shock and rolled over on the bottom. If they recovered they repeated the attempt to go through time and time. They did not learn to avoid the screen from experience.

An electrical expert from the Oregon Agricultural College made extensive experiments at the Bonneville hatchery, but I do not remember

having seen the results of his investigation. It is because of the importance of a knowledge of fish life that I would like to see some biologist associated with this investigation. All such devices have their difficulties, handicaps, and bad features, and I question whether they will work satisfactorily if they are used in the same manner as the electric screens in Yakima county.

Newspaper reports must be regarded with a large measure of tolerance. As a rule they are worth about as much as the paper upon which they are written, since a newspaper man does not know the problem but accepts whatever anybody tells him.

MR. J. W. TITCOMB: Did fish pass through the electric current?

PROFESSOR JOHN N. COBB: They were killed almost invariably.

MR. BAKER: You will recall my previous statement that although I had received these newspaper clippings I chose, before drawing any conclusions, to view the installation personally. We have examined several electric stops among other screens in our survey. Possibly the electric stop problem may be worked out.

MR. H. O'MALLEY: Mr. Cobb made the statement that the present investigation of the Bureau seemed to be based entirely upon its engineering aspect. In that connection I would say that the Bureau feels that it has some of the best biological talent of the country and that its services are available to Mr. Baker at any time. We have viewed the screening of these ditches more from the point of view of an engineering problem which first must be discussed carefully from the standpoint of the present devices. At one time the solving of the fishway problem was turned over to biologists, and I have yet to see much in the way of practical results coming from their work. The Bureau thought highly enough of the pioneer work of McMillan, who has done fundamental research work on the electric screen at the Oregon Agricultural College to put it into print, and it will very shortly come out for public distribution.

## BASS AND OTHER FISH IN IMPOUNDED WATERS

By E. Lee LeCompte

*State Game Warden, Baltimore, Maryland.*

The stocking of impounded waters in Maryland is a very important feature in fish propagation. In the twenty-three counties of the State we have lakes or ponds averaging in size from 25 to 150 acres. These lakes were formed for the purpose of establishing grist mills through the use of water power. A great many of these old mills are still in operation. These lakes furnish excellent aquatic plant life and for the propagation of large-mouthed black bass, crappie, pike or pickerel, rock bass, blue-gill or blue-bream, these areas cannot be excelled. Long before Maryland established fish hatcheries, large mouthed bass secured from the Bureau of Fisheries were planted in a few of these lakes with excellent results.

### BASS

The eastern shore of Maryland is composed of nine counties in which there are located at least fifty of these lakes. The impounded waters contain the large-mouthed bass which is not a native species, but which from plantings has propagated in sufficient quantities to restock large areas. We have been more successful with the propagation of the large-mouthed black bass in impounded waters than any other species. We have not, through our artificial hatcheries, propagated as large an amount of small-mouthed as we have large-mouthed bass. However, wherever the small-mouthed bass has been planted in impounded waters, we find an increase and we believe that we can achieve as great success from planting the small-mouthed bass in impounded waters as we have made with the large-mouthed provided stream conditions are studied and beneficial regulations are adopted. The lakes, to which I refer contain large quantities of vegetable matter and in a majority of cases are surrounded by timber land, thereby providing excellent bass waters.

We have a new proposition confronting us in Maryland, namely, a body of impounded water created by the Conowingo Power Company which has placed an 85 ft. dam across the Susquehanna River, impounding a body of water 13 miles in length from one-half to one mile in width, part of which is in Maryland and part in Pennsylvania. Mr. Swepson Earle, Conservation Commissioner of Maryland and Mr. N. R. Buller,

Fish Commissioner of Pennsylvania, have co-operated in stocking these waters.

The dam was finished in January 1928. During April and May, Maryland planted 12,900,000 yellow perch and 32,000 small-mouthed bass and we anticipate planting 50,000 large-mouthed bass in September. On June 1st, Pennsylvania planted 10,000,000 pike-perch. This area of the Susquehanna River has furnished propagating territory for the small-mouthed bass for years.

The propagation of bass and other fish previously mentioned has probably shown more satisfactory results in our impounded waters than the propagation of trout. However we have been successful in numerous instances with the introduction of brook and rainbow trout in impounded waters, especially waters lying in the western section or mountain districts of Maryland. Our greatest success with trout has been in privately owned small ponds and lakes in the Allegany Mountains of Garrett County. Dr. Henry McComas of Oakland built a lake covering about seven acres damming a small mountain stream known as Herrington Run. This stream had some trout in it which had come from plantings from the State Hatcheries. Within two years after the work was completed this lake was teeming with trout from nine to fourteen inches in length. During the open season of 1927 there were more trout caught from this seven acre area than in any other one section of the State. In fact so eager were the anglers to try their luck at Lake Herrington that we were compelled to put a ban on the limit of fish taken and numbers of persons allowed to fish in this lake.

Another small pond in the same county owned by a Mr. Glotfelty, near McHenry, was stocked by the State in 1925. This gentleman is a butcher and fed his trout on the meat scraps from his slaughter house. He reared 500 out of the 1,000 No. 1. fingerlings planted, producing in two years trout ranging from nine to fourteen inches in size. Browning Lake, on Muddy Creek in the same County, has proved a successful pond for rearing sufficient trout to supply a club which has its headquarters on the lake.

Deep Creek Lake, located in Garrett County, lying in a basin between Meadow and Negro Mountains, is the largest body of impounded waters in Maryland. This lake is about 12 miles in length, running from one-half to one and a half miles in width, and ranges in depth from four to sixty feet. It covers 6,500 acres of blue grass land. It was created by

the Youghiogheny Hydro-Electric Corporation, which built a dam eighty feet in height on the waters of Deep Creek and Cherry Creek, two of the best trout streams in Maryland.

The Department has stocked this lake very heavily with brook and rainbow trout since 1926. However, results have not been satisfactory. The bed of this lake is blue grass meadow land and it is a question in my mind if soil of this character is suitable for the propagation of trout. Another serious setback to the propagation of trout in Deep Creek Lake is the rockbass, locally called "Tint". Our plantings of brook and rainbow trout have only furnished food for the thousands upon thousands of these rock bass which congregate in Deep Creek Lake. During the open season for trout in Deep Creek Lake in 1927 there were a number of brook trout caught weighing from 3½ to 4½ pounds. The number of trout caught from this large area shows conclusively that we had poor success in our plantings. This season we have established holding ponds near the lake and anticipate raising the trout to the legal length, 6 to 8 inches before transplanting them into the waters of Deer Creek Lake. We hope to be more successful in the future with this body of impounded water.

There is no question in my mind that the propagation of trout in impounded waters in Maryland can be made a success. During the distribution in 1927 Mr. Hall Harrison and Mr. Regan Spencer requested they be allotted a few brook trout to plant in a small body of water known as Chattalonee Spring in Baltimore County. Our department went to the expense of building a small dam and impounding a very small body of water, not over 1/16 to ½ of an acre, in which it planted small fingerling trout. These trout which were cared for and fed regularly within nine months had grown to six inches in size.

*Discussion*

MR. I. T. QUINN (Alabama): It is easily possible to produce more pounds of food in the form of fish per acre of water than can be produced in the form of live stock on a similar area of land. Alabama has forged to the front in acreage of impounded waters. When the projects now under consideration are complete, Alabama will have the largest impounded water area of any state in the union; New York and California, I believe, now rank first and second respectively. We are endeavoring to stock our impounded waters, particularly the larger areas, so that we can render a maximum of service to the greatest number of people for sport and food fishing.

To give you an example of what can be expected in the way of fish production in impounded waters, I shall relate one incident which came under my observation on May 18th of this year. At Muscle Shoals we have a large impounded body of water in the Tennessee River, with its tributaries, which is one of the most beautiful and picturesque bodies of water in the entire south. Shoals Creek comes down from the north over the Tennessee state line and empties into the northern banks of Lake Wilson, about four miles above Wilson's Dam. On the date mentioned there were a little more than two thousand men, women, and children fishing for a distance of ten and a half miles up this tributary. During that day it is estimated that more than four tons of fish were caught with hook and line. These fish consisted of large-mouthed black bass, small-mouthed black bass, bluegill, bream, and crappie.

Lake Martin, the largest artificial body of water in the world, located in east Alabama, is being stocked as rapidly as possible with fish suitable to our latitude, principally bass and bream.

During the past three years nearly three-quarters of a million bass and bream have been planted in Lake Martin.

One of the policies of the Alabama Department of Game and Fisheries is to devise simple means of rearing fish in the coves and back waters of these impounded areas. We expect in another year to put into operation inexpensive false dams, made of boards, in the upper stretches of the shallow cove waters so that when the ponds are filled during the winter and spring the bass and bream, in their search for spawning grounds, will go up into those upper reaches. When a sufficient number have arrived for spawning purposes a gate will be lowered so as to cut them off from the main body of water. In the late summer, as these ponds are drawn down by the hydro-electric companies, the gates will be lifted and the fish allowed to pass into open waters. We believe that this method will greatly aid our fish propagation work in connection with impounded bodies of water.

Four years ago we began a campaign in Alabama by sending a letter to the 142 weekly and daily papers of the state, entitled " A Fish Pond on Every Farm". As a result of that campaign more than one thousand fish ponds from a quarter of an acre to twenty-five acres in size were constructed. There is scarcely a community in the entire state in which you cannot find from one to half a dozen fish ponds. We are doing our best to supply bass, especially the large-mouthed bass, in the southern part of the state, and what few small-mouthed bass we can get for the colder waters in the northern sections, and the bluegill bream. We are rearing these three species at our fish culture stations. So far as we have been able to tell, there are no diseases among our fishes in impounded waters and nothing to indicate that there is a lack of normal reproduction in those waters.

## THE GREEN RIVER HATCHERY

By John Mayhall

*Green River Hatchery, Auburn, Washington.*

I have been asked to give a short history of the hatchery which the American Fisheries Society is visiting today. I have been associated with fish propagation in the State of Washington for about thirty years, largely in the construction or development end. During some years, however, I have been engaged in salmon and trout propagation. I have been associated with this particular hatchery from a construction standpoint since 1899 when we cleared the brush away and built a little hatchery out of rough boards. One end was partitioned off to provide living quarters for a man and his wife who looked after the place. The hatchery was built for a capacity of about 2,000,000 eggs. For the first two or three years we succeeded in getting about a million eggs of the silver salmon. Then we decided we could put racks in the Green River, which is fed from the Cascade Mountains north of Mount Ranier. We succeeded in bringing the egg production to about 4,000,000. About 1901 I came down with a construction crew and built a little residence just below the railroad track.

As the years have gone by a gradual increase in the return of the fish has necessitated the construction of new buildings. We moved across Suise creek in 1902 and after the second cycle or return of the fish in 1906 we built, over where the new ponds are, another hatchery and discontinued the original one. We now had a capacity of 6,000,000 eggs. Not many years elapsed before we increased its capacity to nearly double, using the same class of cheap wood construction, because we were feeling our way until the stations should prove themselves worthy of permanent construction.

During the first few years all the fry hatched from the hatchery were liberated into this little creek, due to the fact that there were no roads and no transportation for the distribution of fry. In 1913, when roads began to be built we commenced to haul the young fish further up the Green River and its branches, thus providing a wider distribution and more feeding room.

In 1926 the modern plant was built with a capacity of 28,000,000 eggs. Last year our principal take of eggs amounted to 27,000,000. Estimating 4,000 eggs to the fe-

male, it would mean that between 14,000 or 15,000 salmon were taken during the season out of this small stream. The increase of returning fish runs proportional to the wider distribution of the fry. We are trying to rear such fish as our funds and development permit. We aim to hatch as many eggs as we can take in order that we may protect them during the most delicate and dangerous period, the egg stage. As time goes on our development program will call for the continual increase of rearing facilities.

# FIN ROT IN TROUT

By H. S. Davis

*U. S. Bureau of Fisheries*

During the past two or three years numerous complaints have been received of a fin disease variously known as "fin rot" or "tail rot" which in a number of instances has caused serious mortality. The disease has been reported from a number of widely separated hatcheries at several of which the writer has made a personal investigation of the trouble. It has sometimes been confused with the fin disease caused by Gyrodactylus which is entirely different although the early symptoms may be quite similar.

Fin rot is characterized by the disintegration of the fins which are often entirely destroyed. Nevertheless the disease is sometimes difficult to diagnose since there may be considerable variations in the symptoms probably largely due to differences in the age of the fish and the virulence of the causative organism.

In small fingerlings the pectoral fins are usually affected first, the dorsal fins being attacked next and the disease may eventually spread to the other fins although they are rarely as badly affected as the pectorals and dorsals. In older fish there does not appear to be the same sequence in the order of infection and in many instances the dorsal or caudal fins are apparently affected before the pectorals.

Usually the first noticeable indication of the disease is a more or less distinct white line along the outer margin of the fin. This white streak gradually moves toward the base of the fin while at the same time the outer margin becomes badly frayed owing to the disintegration of the tissue between the fin rays. This process continues until eventually the entire fin may be destroyed. In the late stages of the disease, sores filled with a glistening white pus may develop at the base of the fins and occasionally such lesions are found on the body at some distance from the fins. Due to the discharge of pus into the surrounding water these lesions may appear as small, usually circular, depressions which extend for some distance into the underlying muscles. The sides of such lesions are so clearly defined as to give the impression of a small piece of tissue having been removed by some sharp instrument.

At this stage the disease has been confused with furunculosis but can be readily distinguished from the latter by the character of the lesions. The characteristic sores of furun-

culosis always contain a red pus which is very different in appearance from the glistening white pus found in the sores caused by the fin rot. Furthermore, the development of the sores is entirely different in the two diseases. In fin rot the infection is from the outside so that the more superficial tissues are first affected. As a result the tissues are gradually eroded from the surface forming a lesion which looks as though it might have been eaten out by some small animal. On the other hand, in furunculosis the sores develop from small foci which are usually deeply imbedded in the muscles and gradually extend toward the surface as the bacteria invade the surrounding tissues.

The extent to which the sores develop at or near the bases of the fins is largely dependent on the size and age of the fish. In very young fingerlings death usually occurs before the infection extends beyond the fins so that the occurence of lesions on the body is rare. Larger fish being more resistant may live for a time after some of the fins have been entirely destroyed and therefore there is more opportunity for lesions to develop in the adjacent tissues.

Sometimes in a large fish only a portion of the fin is destroyed. This is especially true of the caudal fin where only a few rays may be affected. The diseased rays disintegrate forming a deep notch or sometimes a hole, in the fin which otherwise appears to be normal.

The causative organism is a rod-shaped bacterium which can usually be found in large numbers on infected fins. The writer has found this bacterium in all cases of fin rot from several different localities and it is apparently the only organism which is uniformly present in the diseased tissues.

As previously indicated, the infection usually starts on the outer margin of the fin. As a result of the irritation caused by the growth of bacteria in this region there is a rapid proliferation of the epithelial cells so that the epithelium becomes greatly thickened. This thickened epithelium forms the white streak across the fin so characteristic of the disease. Later the thickened epithelium is destroyed exposing the fin rays which are also attacked by the bacteria and soon become frayed and broken. On the inner side of the infected area the bacteria are continually invading uninfected tissues which in turn go through the same sequence of events as those infected earlier.

The bacteria develop not only on the outer surface of the fins but also penetrate the tissues where they attack chiefly the connective tissues. In their growth through the

tissues the bacteria follow the lymph channels and can often be seen grouped around the fin rays in great masses. Since the cartilages at the base of the rays are less resistant to bacterial action than the denser peripheral portions they are sometimes destroyed first and the fins may drop off instead of gradually disintegrating. Arriving at the base of the fin through the lymph channels the bacteria begin to invade the surrounding tissues causing the formation of the sores or ulcers previously referred to.

In view of the method of infection outlined above control measures must be directed toward destroying the bacteria before they penetrate the tissues. This can be accomplished by dipping the fish for one to two minutes in a 1 to 2,000 solution of copper sulphate. This method has been found to be effective in early stages of the disease but after the bacteria have gained entrance to the tissues they are out of reach of chemical baths. Usually several treatments at intervals of 24 hours are required before the spread of the disease can be effectually stopped.

Since it is impossible to cure fish in advanced stages of the disease all such fish should be destroyed before beginning the copper sulphate treatment. If not removed they form a continuous scource of infection since great numbers of bacteria pass into the water from the lesions on the fins and body. It is also essential that the troughs or ponds and all utensils used in connection with the diseased fish be thoroughly disinfected.

The disease varies greatly in severity; in many instances only a small percentage of the fish die while in other cases the mortality may be very high. This is apparently due primarily to a difference in the virulence of the bacteria. In the milder form of the disease a large proportion of the infected fish may recover, the lesions heal before the fins are entirely destroyed and the fins quickly regenerate.

The evidence at hand indicates that the disease is very widely distributed and is probably quite common but it is only when it occurs in virulent form that it attracts special attention.

Little information has been obtained regarding the factors which tend to bring on an outbreak of the disease. As in the case of so many other trout diseases, overcrowding is undoubtedly an important contributing factor. There is also evidence that Gyrodactylus may have been involved in some instances. It is very easy to understand how injury to the fins by this parasite might make them more susceptible to infection.

# FORAGE MINNOWS AND BASS CULTURE

By H. S. Davis

*U. S. Bureau of Fisheries*

The last few years have witnessed a marked change in the attitude of the public toward fish culture. The intelligent angler is no longer satisfied with the dumping of large numbers of weak and bewildered fry into our streams and lakes where enemies of all kinds are waiting to receive them with open mouths. There is a constantly increasing demand for larger and better fish; for fish which have reached the stage where they have a reasonable chance of survival when left to shift for themselves.

With trout it is a comparatively simple matter to take care of the increasing demands for larger fish. Given the proper facilities there appears to be no limit to the numbers which can be produced at comparatively small cost, although, of course, there are still many problems to be solved if we are to get the best possible results.

With small and large mouthed bass, however, conditions are very different. Since these fish can not be crowded together successfully in such close quarters as trout and since the young must be reared under essentially natural conditions comparatively large ponds are required with a relatively small production per unit area. As compared with trout this means a much higher overhead which, fortunately, is offset to a considerable extent by lower food and labor costs. Nevertheless, so expensive is the propagation of bass that some of our leading fish culturists have held that the end does not justify the means. In other words they believe that since the production of fingerling bass is so expensive and fraught with so much uncertainty it is economically unjustifiable and that it will be necessary to rely on protective measures, supplemented to some extent by the planting of fry, to maintain a supply of bass in our lakes and streams.

While such a policy may be successful in the more remote and inaccessible localities it is evident that that will necessitate severe restrictions on fishing in waters adjacent to densely populated sections where the number of anglers is limited only by the available space.

In this connection it is well to bear in mind that the great majority of anglers want fish as well as fishing and, what is more important from our standpoint, they are perfectly willing to pay for it. This being the case, it is the obvious duty of

the state and federal fish culturists to provide as good fishing as possible at a reasonable cost and it is evident that this result can not be accomplished in regions of intensive fishing by restrictive measures alone.

No doubt there are waters in which the planting of fry may be economically sound but in most cases it is doubtful if more than a very small percentage of such fry survive for any length of time. Be that as it may, there is good deal of evidence, more or less indirect, in support of the view that under average conditions better results can be obtained by holding the young bass in rearing ponds for several months and planting them in the late summer and fall when they average three to four inches in length. They are then well able to care for themselves and it seems logical to assume that under favorable conditions a considerable percentage should reach maturity.

The greatest obstacle to rearing bass to fingerling size has been the heavy losses sustained during the summer so that only a small percentage of the fish were recovered when the ponds were drained in the fall. It is believed that it is possible to reduce these losses very materially and to produce fingerlings in large numbers at a cost which is far from being prohibitive. Last year in some of the experimental ponds at the Bureau's station at Fairport, Iowa there was a total loss during the summer of less than 50 per cent with a production of approximately 8,000 three-inch large mouth bass to the acre. Of course this was not an exceptionally large production but it should be remembered that the only food which the fish received was produced in the pond so that very little labor was involved. Furthermore, it is confidently believed that this production can be materially increased when our methods are perfected.

In the past, with few exceptions, the common method of rearing bass has been to allow the young fish to remain throughout the season in the ponds in which they were hatched. Sometimes the brood fish were removed, more often they were allowed to remain, but in either event there was little control over the number of fry in the ponds. Consequently they were usually heavily overstocked with the result that the available food was soon exhausted. On the other hand if the fry are removed to nursery or rearing pounds as soon as they leave the nest they have a much better chance of survival since overcrowding can be avoided and only fry of the same age held in each pond.

For the economical production of fingerling bass there should be three types of ponds: spawning ponds, nursery or rearing

ponds and forage ponds. The spawning ponds may be heavily stocked with brood fish and the advanced fry removed from the pond by some such device as the Hesen fry trap. I believe this is a more logical procedure than to attempt to remove the brood fish and leave the fry in the pond since it affords a much greater measure of control over the young bass and also obviates any interference with the vegetation which may have a detrimental effect on the life in the pond.

The nursery ponds should be well stocked with food before the fry are introduced. At first the fry feed largely on small crustacea and insects and consequently *Daphnia magna* with which Hayford has had such notable results in New Jersey makes an ideal food at the same time. But after a short time crustacea and insects can no longer satisfy the cravings of an increasingly blood-thirsty appetite. Something more substantial must be forthcoming and so we find the young bass turning to fish as the mainstay of their diet. Apparently almost any fish, if small enough, may be eaten but it is evident that a decided preference is shown for certain species and their own brothers and sisters form gastronomic tidbits which are easily available. There can be no question that the heavy losses sustained by young bass in hatchery ponds is for the most part due to cannibalism. By providing an ample supply of minnows for the growing bass their cannibalistic tendencies can be largely diverted and a correspondingly larger percentage of bass will survive to serve a more useful purpose.

But not all minnows are equally valuable for bass food. There are certain fundamental requirements which go to make up a good forage fish. Possibly the most important of these is the avoidance of direct competition with the bass for food. Since all young fish apparently feed at first on animal plankton it is impossible to find a forage fish which will not compete to some extent with the bass fry but it is important to avoid species which are likely to require the same food as the bass for any length of time. This, of course, rules out all predacious minnows. If otherwise satisfactory, the most desirable species are undoubtedly those which feed mainly on vegetable material since they utilize a food resource which is not directly available to bass. Such fishes, if readily acceptible to bass, form an ideal means of converting plants and vegetable debris into bass flesh.

Another desirable feature in a forage fish is a late and protracted spawning season. If a fish spawns earlier than the bass the young are often too large to be eaten by fingerling bass until late in the season. This, for instance, is one

of several objectionable features which make the carp an unsatisfactory forage fish. Furthermore, a good forage fish must be hardy, prolific and readily adaptable to pond conditions.

At the present time we are using two species of minnows for forage purposes with good results. The larger of these is the gold shiner, *Notemigonus crysoleucas*, which in some respects appears to be the better of the two, but the smaller blackhead minnow, *Pimephales promelas*, is also an excellent forage fish as brought out by Mr. Lord before this society last year. The superiority of the golden shiner for this purpose rests chiefly on its larger size and wider geographical distribution. Owing to their small size the adult blackheads are readily devoured by fingerling bass before the summer is over which makes it more difficult to maintain a stock of forage fish in the ponds than in the case of the shiner. It is possible that both species may be used in the same pond to advantage since the blackhead minnow is predominantly a bottom feeder while the golden shiner is not.

Although both the golden shiner and the blackhead minnow have proved very satisfactory as forage fish it is by no means certain that there may not be other species which are fully as good, or possibly even better. We hope, whenever practicable, to try out other species which appear to fulfil the requirements of good forage fish.

The forage ponds previously referred to can be utilized to produce both daphnia and forage fish. It has been our experience that unless the spawning and rearing ponds are heavily overstocked with minnows there are very few left when the ponds are drawn in the fall. It is therefore essential to have ponds stocked only with minnows in order to insure having a stock of these fish available at all times.

The exact relation which the forage ponds should bear to the spawning and rearing ponds is a matter which has received relatively little attention. Doubtless, this will depend to a large extent on local conditions. There are obvious advantages in allowing them to drain directly into the bass ponds but this practice is objectionable since the bass usually collect around the inlets in large numbers with a resulting increase in cannibalism.

There is also a question as to the extent to which it will be desirable to rear forage fish for feeding directly to the bass. If the bass ponds are stocked with brood minnows early in the season they can be made to produce large quantities of forage fish as has been shown in the Fairport experiments. To what

extent it will be advisable to supplement this supply with minnows raised in separate forage ponds is a problem still to be solved.

In our experiments at Fairport during the past two years no attempts have been made to feed either the bass or forage fish since we desired first to get accurate data on the production which could reasonably be expected without resorting to artificial foods. Where intensive fish culture is practiced it may be advisable to increase the production of bass and forage fish by artificial feeding and this season we have started some experiments along this line.

While we have not resorted to the use of artificial foods until this year the application of fertilizers to the ponds has been a prominent feature of the experiments since they were inaugurated. In 1926 a mixture of bone meal and dried sheep manure was applied to several ponds at frequent intervals during the spring and early summer but the results were not conclusive. During the following summer (1927) superphosphate was used instead of bone meal with very encouraging results. Several applications of a mixture composed of one part superphosphate to three parts dried sheep manure were made during the early part of the season and in every case the fertilized ponds showed a much greater production than the unfertilized.

The increased production is well shown in the case of four nursery ponds situated close together and of nearly the same size. All four ponds were stocked with forage fish before the bass were introduced. Two of the ponds were fertilized and each produced approximately the same weight of fish per unit area. The weight of the large-mouthed bass fingerlings from the fertilized ponds was approximately four times as great per unit area as that of one of the unfertilized ponds and three times as great as that of the other.

Preliminary observations on the same ponds during the present season show that the bass are again making a more rapid growth in the fertilized than in the unfertilized ponds.

In conclusion there is another thought which I should like to leave with you. If some species of minnows are more desirable for forage purposes than others—as is certainly the case—it should be sound fish cultural practice to encourage the production of these fish in natural bass waters. In waters which are already well stocked with minnows it may not be possible to change materially the relative abundance of the different species but, surely, where there is a deficiency of

desirable forage fish it will not be impracticable to stock with such species as well as with young bass.

In recent years there has been a great change in the attitude of the public toward the treatment of our inland waters. Gross pollution must and will be controlled, even in highly industrialized sections but this alone will not suffice to restore our waters to even an approximation of their original condition. In fact, in many cases as the result of environmental changes such as deforestation, soil erosion and hydro-electric developments such restoration is obviously impossible. However, this does not mean that these waters may not be made as productive as they ever were and in some cases even more so. But this result can not be accomplished by simply stocking such waters with game fish. Fish can not live and grow without food and it is worse than useless to plant game fish in barren waters. If such waters are to be successfully stocked with bass it is essential that an abundant supply of forage fish is assured, otherwise all our labor will be in vain. This state of affairs has happened only too often in the past to the discredit of fish culture and the keen disappointment of the public.

### *Discussion*

MR. J. W. TITCOMB (Connecticut): In such a densely populated state as Connecticut the question of the forage fish in angling waters is rapidly becoming of considerable importance. I have reached the conclusion that in many of our ponds and lakes containing bass, perch, and pickerel, forage fish rather than the angler's fish are needed for planting purposes. In Connecticut we require a license by the men who fish for bait for purposes of sale and do not allow them to fish in our angling waters for forage fish. The angler who wishes to catch his own bait is allowed to do so, but we impress upon him the importance of conserving the bait fish. The conservation of the forage fish is something to be considered in connection with the establishing of good fishing in ponds and lakes.

# WATER TEMPERATURE AND FISH LIFE

DAVID L. BELDING

*Evans Memorial and Boston University School of Medicine.*

It is my purpose to point out the influence of temperature upon fish life from the standpoint of environment, habits, and activities. The material has been compiled from field observations on lakes and streams, from studies in fish environment, and from experimental fish culture. The temperature of the water not only governs the distribution of fish by regulating their physiologic activities, but also is intimately associated with resistance to disease and to adverse conditions of environment such as a reduced oxygen supply and the presence of toxic substances in the water.

## ENVIRONMENT

LAKES.—The changes in the physical characteristics of the country brought about by deforestation, cultivation and manufacturing industries have increased the temperature of the inland waters to the detriment of the valuable cold water species. The fresh water lakes show less change than the streams, since the large shallow lakes as a rule are inhabited by warm water species which are able to withstand increased temperature, while the deep lakes with the cold water species are adequately protected by their depth. The small shallow lakes especially when fed by streams in which the water temperature has been raised as a result of deforestation, show the effect of increased temperature by a change in fish population, the cold water fish such as the brook trout being replaced by the inferior warm water species.

There are two classes of lakes: shallow lakes, large or small, with a uniform temperature; and deep lakes in which different temperature zones are present. In the former the warm water species alone thrive, while in the latter the varied conditions favors both the cold and the warm water species. Depending upon the ratio of depth to area and surface exposure in the deeper lakes, three strata of water are formed: a suface layer, fifteen to twenty feet deep, in which the temperature maintains a uniform level, approximating that of the air; a middle layer, the thermocline, in which there is a rapid fall; and a bottom layer with a uniformly cold temperature. During the fall and spring these layers show a continous rearrangement and readjustment with a complete reversal in winter.

The surface temperature when at its height during July

and August is usually slightly lower than the air, reaching its maximum temperature more slowly and holding the heat longer. In exposed small shallow lakes sudden fluctuations in temperature between day and night temperatures may produce an unfavorable environment. In one instance in unshaded hatchery pools of warm water fingerling trout died in large numbers as a result of sudden temperature fluctuations.

The number and size of springs in small bodies of water regulates to a considerable degree the temperature of the water. Changes in the shores through deforestation, drainage and an artificially raised water level tend to modify the original character of spring-fed lakes. The source of cold water supply is dimished and a larger surface area is exposed to the warming rays of the sun. In some instances the reduction of the water level in shallow lakes by decreasing the depth will raise the temperature.

STREAMS.—The fresh water streams show the effect of an altered environment by an increased and a fluctuating temperature. Streams once suitable for the cold water species have become unsuitable because of conditions resulting from the high summer temperature of the water. Although it is impossible to separate a single factor such as temperature from other environmental conditions, it is nevertheless safe to state that temperature is an essential factor in determining a suitable habitat for fish.

1. CRITICAL TEMPERATURE.—The period of critical temperature is limited to a short time in midsummer. If the period of maximum heat happens to coincide with that of maximum drought conditions are still more unfavorable. It is extremely difficult to predict for an individual stream the fluctuating temperatures which may occur under a variety of conditions, but as an approximate guide the correlation table of Embody (1) between air and water temperature for brook, brown, and rainbow trout streams, is of considerable value. The maximum temperature of a stream depends upon the rapidity with which clear hot days and warm nights fall in succession, such runs producing unexpectedly high temperatures.

2. FLOW.—Deforestation has changed the character of stream flow. Under primeval forest conditions the ground was covered with humus, limbs, logs, which gradually released the absorbed water, thus insuring a uniform flow. Owing to the deforestation and the absence of the sponge-

like covering, the streams rise quickly, flow rapidly, and soon subside after each rainfall, resulting in diminished volume of flow during the dry summer months and changes in the stream bed. Lack of water in a stream, particularly of the mountain type, in periods of drought renders it unfit for trout life by the reduction of flow, by the isolation of fish in small pools and by the increased temperature of the water. Most streams in their upper waters are fed by springs, which are supplied ultimately by the surface rainfall.

Rapidity of flow is associated with a variable volume. The torrental mountain streams with their large, deeply cut beds are the first to become dry or be reduced in volume, since in a short time they carry off the accumulated volume of water. As a rule these streams except in their lower reaches have a fairly low temperature, owing to the numerous springs along their course and the abundance of shade. The size, shape, and material of the stream bed affect the temperature by influencing the volume and rate of flow and by the absorption of heat by the underlying soil. The presence of large exposed bowlders or ledges in a stream bed tends to increase the temperature.

3. SPRINGS.—Brooks fed by large springs usually have cold water. The upper waters of a brook are formed by springs and for the most part lie in shaded areas. Deforestation and cultivation have reduced the volume of these springs and increased the temperature of the water by removing the protecting covering. If protected by shade, springs along the course of a stream tend to maintain a low temperature.

The value of springs as a means of maintaining a low temperature in streams has been overestimated. The cold springs at the source do not influence the temperature of the lower reaches unless the stream is well shaded or unless there are springs or cold spring-fed feeders along its course. All water received from springs is not cold. Water coming from an exposed spring at a distance may be warm by the time it joins the stream, as in the warm spring-fed swamp stream. The temperature of a stream is lowered in direct proportion to the ratio of stream volume to the volume of cold water feeders and springs.

4. SHADE.—Shade is the most important factor in maintaining a low temperature in streams. The temperature will rise and fall on bright warm days in proportion to the exposure. Deforestation not only has changed the volume and rate of flow but has removed the protecting covering.

Such a change may be readily discovered by taking the temperature of a cold stream as it emerges from deep woodland and retesting the same stream after it has taken a winding course across open meadow land. In one stream a rise of nearly 10 degrees Fahrenheit was recorded in two miles of open meadow and a partial recovery of 6 degrees after the same stream had passed through one mile of woodland.

In streams which are exposed to the direct action of the sun bright warm days alternating with cool nights produce marked fluctuations of temperature. A gradual change from a low to a high temperature can be tolerated by brook trout, whereas a sudden change over the same range may prove unfavorable or even fatal. Some form of shade should be left by riparian owners in the interests of fish preservation. The practice of cleaning off all brush and overhanging bushes along meadow streams should be condemned. Trees prevent the direct rays of the sun from reaching the water, keep the air cool over the water, and prevent the stream bed from absorbing heat. Underbrush, although not as effective as woodland, materially shields the water from the sun.

5. DAMS.—The temperature of many cold water trout streams has been raised by the construction of small shallow ponds along their course, thereby permanently raising the temperature of the water and producing conditions favorable to other species of fish. This condition occurs under natural conditions in country inhabited by beaver. More often it is caused by damming of the stream for commercial or artistic purposes. Unless the stream flow is of good volume and the pond deep or heavily shaded, the temperature of the water at the outlet will be raised several degrees above that at the inlet. The practice of damming small trout streams should be discouraged unless conditions are such as to produce deep shaded pools.

## PHYSIOLOGIC ACTIVITIES

BODY TEMPERATURE.—A fish is a cold-blooded, or more correctly speaking, a poikilothermal animal. Its temperature fluctuates with its environment and is slightly above that of the surrounding medium. Simpson (2) found that the body temperature of the cod averaged 0.36 to 0.46 degrees Fahrenheit above that of the water.

RANGE.—Considerable variation exists between different species of fish as regards temperature ranges. The brook trout, a cold water species, can survive a moderately high temperature and can live in apparent comfort at a temperature between 70° and 80° Fahrenheit, although it prefers cooler waters. However, it is susceptible to sudden changes in temperature. In one experiment brook trout transferred from water at 54° Fahrenheit to water at 85° died in less than three minutes, whereas those survived which were placed in water at 80 degrees. Aquarium goldfish have died when transferred from water at 72 degrees to cold tap water. Such observations emphasize the necessity of gradually equalizing the temperature of water in planting fish in a new environment, a practice long followed by fish culturists.

Brook trout will live in waters of a higher temperature than their normal habitat but they become more susceptible to adverse environmental conditions. The bullhead, a warm water fish when placed in spring water of 55 degrees Fahrenheit will live for a few days or weeks but eventually it will die from fungus infection due to lowered vitality.

RESPIRATION.—The oxygen, required for metabolism, is obtained from the dissolved oxygen in the water by means of the gills, which bring the blood in close contact with the water. Oxygen is absorbed and carbon dioxide and waste products are given off through the epithelium comparable to the respiratory exchange of air breathing animals. The normal respiratory movement whereby the gills are bathed with water through the combined action of mouth and gill covers is regular as to rate, volume, and force, and only irregular when interrupted by a sudden movement or an occasional forceful gulp. The rate varies with species, individual, size, activity of the fish, and with the oxygen, carbon dioxide, sediment, and temperature of the water.

The increased rate of respiration due to the high temperature is not proportionate to the decrease in dissolved oxygen and appears to be due to increased metabolism. Excessive increase beyond the normal limits for certain species may produce pathologic changes in respiration but within the normal range there is a compensatory increase in rate. In the carp the rate varies from 28 to 42 at a temperature of 38 degrees Fahrenheit and from 56 to 76 at 57 degrees Fahrenheit.

REPRODUCTION.—The spawning season of aquatic animals is markedly influenced by temperature. Along the Atlantic seacoast the spawning of various fish and mollusks occurs earlier in the southern waters and later in the northern. In New England waters many marine mollusks require a minimum temperature of 60 degrees Fahrenheit for spawning. Fish, particularly the anadromous species, differ in the time of spawning but for each species there is a definite temperature at which the development of the sexual elements takes place. In the case of the alewife, after the temperature of the water has reached 50 degrees Fahrenheit the rate of development of the fertilized egg progresses in proportion to increased temperature until at 70 degrees the maximum is reached. In fresh water fish the time of spawning differs between the cold and warm water species; e. g., brook trout in the fall and bass in the early summer.

GROWTH.—Growth is governed by the abundance of food and by the rate of metabolism of the fish. The fish population of any body of water depends ultimately upon the abundance of plankton life. The supply of plankton forms, upon which the small fish and larger aquatic animals subsist, is determined by the temperature and the mineral and organic material in the water. Likewise, the growth of the larger aquatic plants, which furnish resting places for the animal food forms, is stimulated by a high temperature. Irrespective of food supply fish culturists have demonstrated that within certain limits fry and fingerling trout grow more slowly in cold water than in warm. Because of the excessive midsummer losses warm water trout hatcheries are only of value for rapid growth in fingerlings which can be planted early.

A striking instance of the effect of temperature is the cessation of growth during the winter in the scallop, quahaug, and oyster in New England waters. Shell formation, an outward manifestation of the growth of the soft parts, does not start in the spring until the water has reached the temperature of 45° Fahrenheit and ceases at approximately the same temperature in the fall. Cessation of growth apparently depends upon the reduction of metabolism by the temperature.

DISTRIBUTION.—Each species requires a certain temperature for optimum living conditions. It also has a range above and below which conditions become unsatisfactory for its

existence. When these limits are exceeded it is necessary for the fish either to adjust itself to the new environment or to seek elsewhere a more favorable habitat. The brook trout, an inhabitant of cold swift water, may be found in waters inhabited by warm water species but it does not develop as well as in its natural environment. Similarly the warm water species do not flourish in cold water suitable for trout. Increasing the temperature of a stream tends to bring about alterations in the natural conditions, and the ultimate replacement of the brook trout by inferior warm water fish.

The annual periodic migration of fish to spawning grounds is influenced by temperature. The alewife, an anadromous fish, first enters the coastal stream when the temperature of the water has reached 50 degrees Fahrenheit. In Massachusetts the run in the warmer waters of Buzzard's Bay is nearly a month earlier than in the colder water on the north side of Cape Cod. Temperature also regulates the migration of fish which during warm weather seek colder localities.

## PATHOLOGICAL CONDITIONS

The temperature of the water is an important factor in the resistance of the fish to adverse environment or disease. As a rule low temperatures increase the resistance of the fish and decrease the effect of injurious agents. The optimum temperature for the existence of each species is that of its greatest resistance.

OXYGEN DEPLETION.—With increased temperature the respiratory movements of the fish become more rapid because of increased metabolism and because the available supply of dissolved oxygen in the water is diminished. Beyond a certain limit for each species the depletion of dissolved oxygen becomes pathologic in the sense that it produces abnormal respiratory movements and eventually may cause the death of the fish. In such instances the onset of symptoms and the death of the fish is more rapid at a high than at a low temperature. Closely related to oxygen depletion is the increase in carbon dioxide.

CHEMICAL POISONS.—Sudden temperature changes may result from the rapid influx of hot water or hot trade waste into a stream, but the effect is strictly local and is of relatively little importance. The action of various toxic substances such as irritating acids, alkalis, and toxic salts is accelerated by warm water. Observations upon brook

trout indicate a more speedy death and a more rapid onset of symptoms when the temperature is above the optimum range. This condition appears to be due to lessened resistance and to acceleration of chemical irritation of the delicate epithelial covering of the gill filaments, a high water temperature producing earlier symptoms of distress.

TOXIC GASES.—The concentration of hydrogen sulfid which will cause death varies for different species of fish. Below the lethal dose the fish are able to tolerate the poison by rapid oxidation in the blood. The colder the water the greater is the amount of hydrogen sulfid required to produce death. At 40 degrees Fahrenheit thirty-four parts per million of hydrogen sulfid were required to produce death in carp within seventeen hours, whereas at 65 degrees Fahrenheit the same result was produced with six parts per million.

DISEASE.—The temperature of the water is of the utmost importance in the handling of fish diseases, whether these conditions are due to infections, parasites, or the result of nutritional and developmental disturbances which lower vitality. A temperature above the optimum range increases the onset of symptoms and the rapidity of death. It lessens the general resistance of the fish and, in many bacterial and protozoan diseases, favors the multiplication of the invading organism. A high temperature is favorable for epidemics of bacterial disease. Observations upon the epidemics caused by *B. salmoncida* indicate that a temperature of 50 degrees Fahrenheit is necessary for the spread of the disease and that with certain strains of the organism severe epidemics do not exist until a temperature of 60 degrees Fahrenheit is reached. With inoculated trout the time of death varied from two days at 65 degrees Fahrenheit to five days at 55 degrees Fahrenheit. In water below 55 degrees Fahrenheit the diseased fish showed local lesions such as abscesses and ulcers which were absent at higher temperatures. The fish culturist who possesses an ample supply of cold water has one means of protection against bacterial disease since certain epidemics can be held in check by a low water temperature. In a few parasitic infections a high temperature is unfavorable to the parasite.

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# THE PACIFIC RAZOR CLAM FISHERY IN THE STATE OF WASHINGTON[1]

By H. C. McMillin

*U. S. Bureau of Fisheries*

The Pacific razor clam (*Siliqua patula*, Dixon) is found from Pismo, San Luis Obispo County, California, to the Bering Sea. The most productive beds are those along the coast of Washington from the Columbia River to Copalis Rocks, where over 38 miles of beach are worked by commercial diggers. The width of the producing belt is about 150 yards and the total area of the beds is estimated to be 2,080 acres. Since 1908 these beds have produced on an average over 35,000 cases of canned clams annually. Fishery statistics of the State of Washington shows that 481,480 cases were canned during the period 1915 to 1927 inclusive. This gives an average annual yield to the commercial fishery of 37,037 cases per year or 17.8 cases per acre. Since 30 pounds of raw meat are required to fill a case we have an indicated production of 534 pounds of cleaned meat per acre per year. It is not assumed that this figure represents the total production. In recent years these beaches have become important summer resorts and clam digging is a popular pastime. It has been estimated by some canners that the tourist consumption of recent years has equaled the commercial catch. No figures are available for comparison but the amount used by tourists probably has amounted to about 30 per cent of total catch in the last five years.

Between 1915 and 1923 illegal canning exacted a further toll from the beaches. During the autumn of 1922 at least thirty-five plants of various capacities were canning in closed season. The unreported pack of these operators probably formed about one half of the total annual output. In the winter of 1922-23 a determined effort on the part of the state fisheries authorities materially reduced illegal operations but did not entirely suppress them. Intensive digging has reduced the clam population but a remarkable output has been maintained during 20 years of operation.

This heavy yield of protein food is made possible by two factors, (1) the regular set of young clams and (2) the rapid growth of the clams. Every year young clams appear about the first of August in large numbers just under the surface of the sand. In years of very heavy set crowding causes the death of a large number but all observations indicate that the

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beds are seeded every year, with excessive sets occurring every three or four years.

A small amount of sexual products are liberated at the age of two years when the clams measure from 2½ to 4½ inches in length. Each year thereafter the sexual products equal about 30 per cent of the body weight. At seven years of age the clams are between five and six inches in length.

The razor clam lies buried in the sand in the intertidal zone with the siphon extended nearly to the surface but covered with a layer of sand to prevent detection. When the ground is jarred by a person walking on the beach or by striking with a shovel the neck is withdrawn leaving a depression in the sand which reveals the location of the clam. Upon being disturbed further the clam retreats rapidly through the soft sand and if not taken quickly will descend to a place of safety beyond reach of the digger. Only in summer when the tides are very low and the water drains out of the sand do the clams find it impossible to go through the sand at a rate of several feet per minute. The diggers work in the edge of the surf or as low as possible on the exposed beach. As the holes appear in the sand the clams are dug one at a time. Methods employed in taking other clams, where the ground is systematically dug over, is impractical due to the speed with which this species retreats where digging is in progress. Operations start about one and one-half hours before low tide and continue about two and one-half hours. Only about one-half of the low tides expose the clam beds.

The diggers deliver their clams to the cannery or to buying stations called "weigh sheds" maintained by the canners on the beach. In order to remove some of the sand which clings to the shell the clams are run over a screen before being weighed. They are sold by the pound at a price which varies with market conditions and the scarcity of labor.

At the cannery the clams are immersed in hot water or live steam to remove the shell. They are then run onto a conveyor where the meats are removed and shells are carried outside. In order to prepare the clams for canning the siphons are opened and the internal organs and all pigmented portions are removed. The sand which clings to the edge of the mantle and remains in the body is then removed by careful washing. The product when ready for canning is a clean white piece of meat which has been cleaned as carefully as a beef. The majority of the clams are minced, only a few being canned whole. The product commands a ready market and is sold almost exclusively on the west coast.

HISTORY OF THE COMMERCIAL CLAM FISHERY. Canning of razor clams actually started in Oregon, but for 25 years the scene of major operations has been in Washington. Up to 1910 the pack was limited by the amount that a restricted market would absorb. Then followed a period of market expansion, which resulted in the opening of new canneries in Alaska in 1915 and in an increase in the intensity of digging on the Washington coast. There was a limited pack during the war period due to the lack of diggers but more recent years have seen a great increase in both clammers and output.

Table 1 shows the number of licenses issued each year since 1916 and the total catch of clams in pounds taken by commercial diggers. The figures submitted by the canners since 1921 give an accurate record of the amount of clams taken in these years. The average annual "dig" per license is calculated from these figures. A decline in the catch from year to year of all diggers regardless of experience indicates a reduced efficiency in digging effort.

TABLE 1. PRODUCTION OF RAZOR CLAMS

| Year | Number licenses issued | Clams reported by diggers Pounds | Clams reported by canners Pounds | Clams per digger Pounds |
|---|---|---|---|---|
| 1916 | 347 | 1,396,355 | ..... | ..... |
| 1917 | 284 | 825,555 | ..... | ..... |
| 1918 | 304 | 1,665,733 | ..... | ..... |
| 1919 | 476 | 2,963,218 | ..... | ..... |
| 1920 | 418 | 3,040,758 | ..... | ..... |
| 1921 | 608 | 661,883 | 3,620,484 | 5,955 |
| 1922 | 1222 | 2,195,613 | 4,208,241 | 3,444 |
| 1923 | 1002 | 783,991 | 1,622,737 | 1,619 |
| 1924 | 823 | 451,259 | 2,060,272 | 2,503 |
| 1925 | 1093 | 533,123 | 1,718,771 | 1,573 |
| 1926 | 1449 | 656,891 | 2,542,600 | 1,754 |

In order to obtain a more accurate picture of the true condition of the fishery the catch of experienced diggers was considered. The records of ten men having five years experience prior to 1919 were taken from the Washington State Fisheries Commission's files. The average catch per man for each year was determined. These figures are shown in Table 2 and in Figure 1 they are reproduced graphically together with a line showing the trend of the records. If the number of clams on the beach were constant, the trend of the line would be upward because the catch would increase as a result of further experience of the diggers. These records show a decided and constant decrease which indicates a reduction in the clam population.

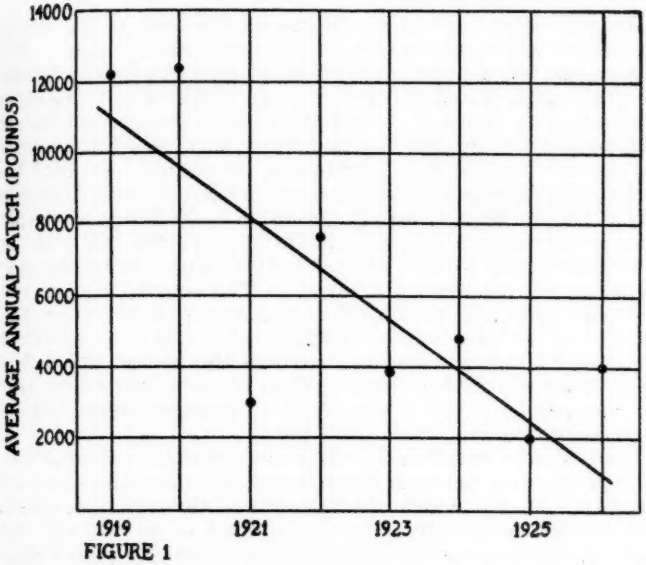


FIGURE 1

Figure 1. Graphic representation of the average number of ponds caught by ten experienced diggers. The heavy line shows the general trend in the quantities caught.

In order to maintain the pack it was necessary to increase the number of diggers. In 1918 the state issed 304 licenses. This was about the average number issued in previous years. Available figures for 1928 show a sale of about 3,070 licenses, or about ten times as many as had formerly been issued. Within certain limits it is possible to maintain a fairly constant production by increasing the digging effort, but conditions on the Washington beach are rapidly approaching the point where the present pack can not be maintained regardless of the amount of labor employed.

TABLE 2. THE AVERAGE ANNUAL CATCH OF TEN EXPERIENCED CLAMMERS.

| Year | Average Catch Per Man |
|---|---|
| 1919 | 12,153 |
| 1920 | 12,346 |
| 1921 | 3,093 |
| 1922 | 7,698 |
| 1923 | 3,890 |
| 1924 | 4,782 |
| 1925 | 1,967 |
| 1926 | 3,995 |

Another index to the conditions of the beds is the age of the clams which are taken in the commercial catch. For comparison the proportion of clams of each age for the catches of 1923, 1927, and 1928 are given in Table 3 and presented graphically in figure 2. In 1923 most of the clams were six and seven years of age, two and three year olds did not enter the commercial catch in significant numbers. In 1927 the bulk of the catch was four years old while two and three year olds made up 30 per cent of the total. In 1928 twenty per cent of the catch were two and three years old and even the first year group formed an appreciable part; specimens over six years of age were not taken. The clams listed as two years old were taken before they had spawned, therefore 42.5 per cent of the total number of clams taken had not reproduced and over 83 per cent had not reached the age at which they were important as breeders. Thus in each succeeding year the commercial catch is composed of younger clams and we are now approaching the lower limit.

The taking of small clams comprises a distinct economic loss. At each operaton between digging and canning small clams are wasted. At the weigh sheds they fall through the screens and are not recovered; they are allowed to go out with the shells at the cannery; the cleaners throw some away and when they are cleaned the product is very small in amount. If clams less than 4½ inches in length were left to grow for another year they would produce two or three times as much cleaned meat.

TABLE 3. AGE OF CLAMS IN THE COMMERCIAL CATCH.

| Age | 1923 Per Cent | 1927 Per Cent | 1928 Per Cent |
|---|---|---|---|
| 1 | 1.2 | 0 | 11.1 |
| 2 | 1.6 | 8.3 | 31.4 |
| 3 | 1.6 | 22.0 | 40.6 |
| 4 | 13.1 | 49.1 | 11.1 |
| 5 | 19.6 | 11.5 | 4.3 |
| 6 | 24.1 | 2.3 | 1.4 |
| 7 | 24.9 | 5.0 | 0 |
| 8 | 12.3 | .9 | 0 |
| 9 | 1.6 | .9 | 0 |
| 10 | 0 | 0 | 0 |

The practice of taking these small clams is certainly indefensible in view of the rapid growth which would follow if they were left and the resulting waste in the process of preparing them for canning. It is possible to avoid taking them in large numbers because the diggers in most cases recognize the "holes" of small clams and even if dug they could be returned

FIGURE 2

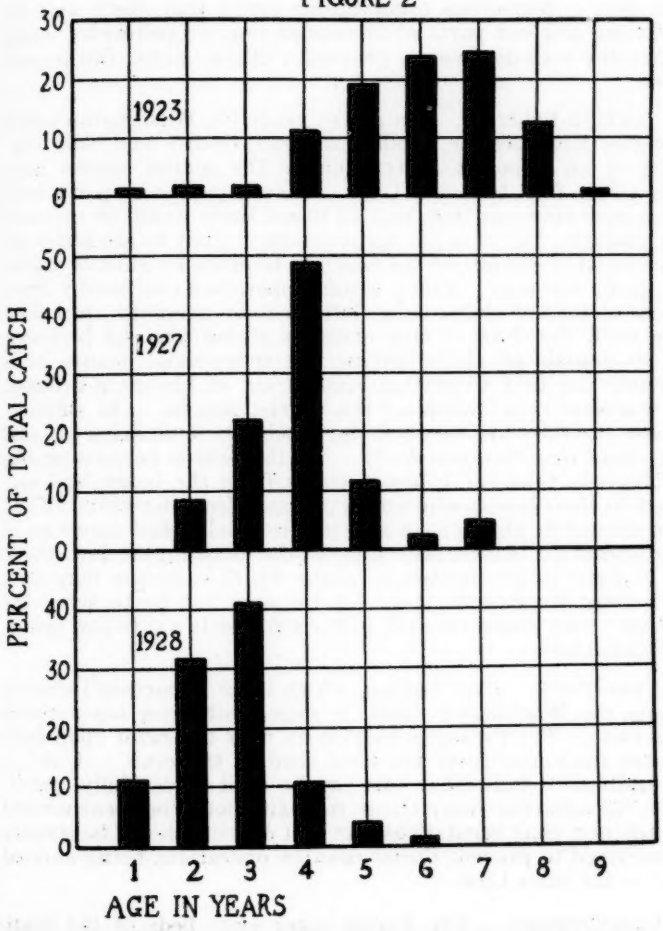


Figure 2. Graphic representati n of the number of clams of each age in the commercial catch for the years 1923, 1927, and 1928. In 1923 seven years was the most frequent age. In 1927 and 1928 four and three year old clams respectively were most frequent.

to the beds. Some persons claim that any clam receiving an injury or sustaining a cracked shell will die if returned to the bed. Numerous observations prove that shells may be repaired and lost parts of the siphon may be restored. Only when the body is severely crushed will the animal fail to survive.

TOURIST PROBLEM. In recent years the Washington ocean beaches have become popular summer resorts and clam digging is an important attraction. The tourist season lasts from July first to Labor Day. If each person or party took only such clams as they wanted to eat there would be no tourist problem, but it is not an uncommon sight to see boxes or buckets of clams left on the beach to be eaten by gulls or washed up by the tide. Camp ground operators continually complain of tons of clams being left on their property until they are unfit for food. One operator stated that he had dug 3,000 pounds of clams during the commercial season of 3 months and took twice that amount out of his camp grounds in garbage each month of the tourist season. In summer where the tides are very low the beaches become dried out and the clams may be taken easily. At this season persons posing as tourists take car loads of clams from the beach and can them at their homes where they are safe from detection. They are canned in glass or tin and sold in small retail stores or to restaurants. Since, according to the Washington law, there is no limit in the amount of clams which a person may take "provided he intends them for his own use or to serve his guests" such illegal canning in the summer is a safe and profitable occupation.

CRAB BAIT. Crab fishing, which is an important industry along the Washington coast, is dependent upon razor clams for bait. The fishing is carried on near the razor clam beds where the clams form the local food of the crab. Until it is established that other bait can be used successfully, provision for securing razor clams for bait should be incorporated in any new clam regulations, but bait digging should be strictly supervised to prevent illegal canning operations being carried out at the same time.

CONCLUSIONS. The Pacific razor clam beds of the State of Washington cover about 2,080 acres and have produced over 700,000 cases of canned product in the last twenty years. Clams dug by local residents and tourists have amounted to about one-third of the commercial catch in the last five years.

Illegal canning has drawn still further upon the resources. The pack has been maintained by the employment of a large number of diggers but at present it is no longer possible to maintain the pack at the present level. The catch of the individual digger has shown a rapid and constant decrease in recent years until it is not profitable for men to devote their time to digging. Each year younger clams are taken. In 1928 nearly half of the number of clams taken had not spawned. The taking of clams less than four and one-half inches in total length of shell is a direct economic loss. The consumption of clams by tourists is increasing each year and many clams are wasted. Illegal canning can be carried on successfully under the present law and should be prevented by further regulations.

RECOMMENDATIONS. A size limit should be established which would prevent the taking of clams less than four and one-half inches in length. A bag limit should be imposed upon all unlicensed diggers. A limit of two dozen clams per person per day would allow enough for private consumption and prevent illegal canning. The beaches should be completely closed from October 1st to March 2nd, the latter being the opening date of the commercial season. Allowance should be made for securing clams for bait by crab fishermen.

## HIGH DAMS AND FISH

In connection with the installation of fishways an open forum on the important problem of the passage of fish returning to the ocean over high dams was held. The discussion was led by Prof. John N. Cobb, Dean of the College of Fisheries, University of Washington.

PROFESSOR COBB: One of our great problems is to get the young fish safely to the sea. As far as the Pacific salmon are concerned there is no problem as they die on the spawning ground, but the steel-head trout do not die. Representing the fishing industries of the State of Washington, I was a member of the joint Committee composed of representatives of the Oregon Fish Commission, the Washington Department of Fisheries, and the Northwest Electric Light and Power Association for the investigation of fishways. As part of this investigation the problem of getting fish down over high dams was considered. One of the tests was made in July 1925 on the Spokane River at the Long Lake dam of the Washington Water Power Company, which has a height of one hundred and fifty-one feet. Owing to the slope of the dam the actual distance traversed by fish in passing over it was one hunded and seventy-one feet. At the foot of the dam was a pool averaging forty feet in depth, extending the full width of the dam.

Thirteen brook trout, 13 to 15 inches in length, were enclosed singly in open mesh bags 18 inches long, to which a light wooden float, 8 x 2 inches, was attached by a ten foot line. A stream of water 10 feet in width and 3 to 4 inches deep was passing down the face of the dam from one of the central gates. The enmeshed trout were dropped from the bridge, 20 feet above the crest of the dams, into the stream of water issuing from the gates. With lightning like speed they were carried to the bottom where they were picked up as quickly as possible by men in a boat, who recorded the condition of the fish.

Three trout were dead, one was in an exhausted condition, one had lost an eye, and eight appeared normal. Two of the dead fish had remained close to the dam for nearly 10 minutes before being rescued. The bag probably had considerable to do with the partial exhaustion of the fish, but its use was necessary in order to recover the fish. The live fish were returned to the hatchery and kept under observa-

tion for one week to observe any possible delayed effect. From this test we may conclude that if there is a suitable pool at the foot of the dam, fish may descend safely.

MR. T. SURBER (MINNESOTA): Observation of the fish under natural conditions might throw some light on the question of survival. In 1907 while conducting a fish cultural operations in western North Carolina, I had most successful rainbow trout fishing at the foot of a fall with a sheer drop of 70 feet immediately below the outlet to an artificial lake near Ashville. We caught a lot of spawners near the outlet of the lake with a seine. It was impossible for those fish to have come up stream because there were a series of falls below varying in height from 50 to 75 feet. None of the trout showed any scars or other indication of damage from passing over the 70 foot fall.

PROFESSOR COBB: On several occasions I felt sure that fish had gone over a dam safely, but it is difficult to prove it. In this case, however, we could follow the fish through the whole stage of the operation.

MR. H. O'MALLEY: Is it not necessary, where high dams are constructed and where there is a tendency on the part of the power companies to utilize all the waters during the greater part of the year, to provide for an overflow if we are to have any reasonable migration of the fish down stream?

PROFESSOR COBB: My experience, extending over four or five years in connection with this problem, is that water companies never let water escape if they can help it. For instance, they will switch one plant on to a certain load, thus lowering the water; then perhaps for another few hours by switching to some other plant they will raise the water level. Only at this time will any water go over the dam except in times of freshet. Every time we have conducted experiments we have had to make special arrangements with the water power company to allow some of the water to go over the dam, because the water supply is so precious.

MR. JOHN C. VEATCH (OREGON): The great problem we have at the present time in the State of Oregon is that of power development on the streams. Some of our streams which are excellent propagating waters are likely to be destroyed by the development of power projects. For instance, the Rogue River, the McKenzie, and the upper Willa-

mette. All these streams have proposed power sites which, if developed according to present plans, will prevent the running of fish up and down the streams. We have made one step forward this year by getting the state engineer department to refuse to grant a permit for a power site on the McKenzie River until the fishing interests are taken care of, with the approval of the State Fish Commission. We hope to make this power plant a model in the matter of providing means of taking the fish up and down stream. The permit provides for a minimum flow of water through the original stream bed, and that flow can at all times be controlled by the State Fish Commission of the state.

# DEVELOPMENT OF OYSTER INDUSTRY OF THE PACIFIC

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The oyster industry of the Pacific coast differs entirely from that of the Atlantic. In the Atlantic the one species of oyster forms the basis of the entire industry along the whole coast. On the Pacific coast there are really four species of oyster. The California oyster, or rather the Gulf of California oyster, which is in Mexican waters has not been developed on commercial lines in this country. A small supply has been brought out of Mexico, but the fishery is not yet on a commercial basis. Of the three species on the rest of the coast the most important is the native oyster, commercially known as the Olympia oyster, because the centre of the industry is in a series of bays radiating out from Olympia, the southern section of Puget Sound.

Native Oyster—The native oyster, when it first became known to the pioneers, existed in great beds, particularly in the Sound region, and on a still more extensive scale in the great bay to the north of the Columbia River, Willapa harbour. It existed also in some of the bays in Oregon, Yaquina Bay and other sections of the Oregon coast, Humboldt Bay in California, and extended as far as British Columbia. These beds were utilized by the native Indians and the pioneer settlers, but the drain upon them was very slight until the cities began to develop on the Pacific coast, particularly in California, when the practice developed of shipping these oysters down from Willapa harbour, Yaquina Bay, and later from Puget Sound to these large markets. Schooner-load after schooner-load was taken from these regions to the south. The methods of taking were destructive. Indians were largely employed in gathering the oyster and extremely irrational methods from the standpoint of conservation were used. The common practice in those early days was to gather all the material from the beds, sort out the oysters of commercial value, and leave the culls on the beach. The oysters were shipped and no shells were ever put back in the waters. The result was that the production of oysters gradually rose until about a hundred thousand bushels of oysters were shipped annually from Willapa harbour; finally production reached the peak and began to

run down. In the nineties the industry began to wane and at the present time, it is practically non-existent. A few hundred bushels of oysters are taken out of Willapa harbour at the present time, but the industry is practically gone,—an illustration of destructive methods of fishing.

In the southern section of the Sound, for a time a similar destructive system was employed and the result was that areas were either entirely destroyed or greatly depleted. As cities began to grow in the Sound region, the demand increased and the prices went up. In view of increasing the supply, the oyster men of the Sound region, who are a rather intelligent group of men, organized and tried a great many different experiments to increase the supply. The method that was finally worked out was based in part upon the French technique and in part on that employed in the eastern oyster areas. Areas suitable for the cultivation of oysters are leveled off and surrounded by a dike either of concrete or of creosoted timber, so as to keep a volume of water constantly over the oyster. Then they deposit the shells of the native oyster or other mollusks, at the proper time of the year, when the larvae are swimming; the little oysters attach themselves to those shells, and the result is a new supply of oysters. In that way they have re-established and gradually built up a decadent industry to a flourishing condition; which is good illustration of the application of knowledge of the biology of the oyster to its conservation. About 60,000 bushels of oysters is the present annual production in the Sound region and there is a greater production of oysters in the Sound region than ever existed even in the most palmy days of the industry. First class oyster land is valued at from $5,000 an acre up.

EASTERN OYSTER—The other industry is concerned with the eastern oyster. From small, immature eastern oysters which were brought from the east coast in refrigerator cars and planted in San Francisco Bay, the industry spread up the coast and developed on quite a large scale in Willapa harbour, where it displaced for a time the decadent native oyster industry, and from there spread to the Sound region. Many companies were formed in Puget Sound and in British Columbia, as well as in some of the arms of the sea adjacent to Puget Sound, as Hood's canal for the exploitation of this industry. However, after a period of development the industry underwent a rapid decline, because, owing to the necessity of growing the oysters on the exposed flats in an unnatural environment, scarcely more than 25 per cent of the planted seed

oysters reached maturity. The companies went bankrupt, and the eastern oyster practically disappeared from the Sound region, where they no longer are grown. The Willapa harbour industry persisted for a longer time, but ultimately it declined until only two companies are now operating in the Willapa harbour region.

The eastern oyster in our waters never reproduced naturally, with the single exception of the Nasel River at the southern end of the Willapa harbour. Set was obtained from a large quantity of eastern oysters bedded in the shoals of the river. This industry which was controlled by the Long Island Oyster Company and operated largely by east coast oyster men, persisted owing to the continuous supply of seed oysters produced on their grounds. Unfortunately its methods of conservation in the lower waters of the Nasel are not of the highest type. Because of shortage of funds it has skimmed this estuary as completely as possible and has removed every oyster they could find. There was a public area further up the estuary in which there were a great many large spawning oysters. This year another company has been organized to exploit that part of the estuary. It is possible that the reduction of the number of spawning oysters may eventually result in their extinction.

JAPANESE OYSTER—Many years ago it was suggested that the eastern oyster on our coast might be replaced by this large, fine oyster. Many sporadic attempts were made to introduce the Japanese oyster and finally a Japanese company was organized in Seattle. On ground a little south of Bellingham it proceeded to carry out a series of experiments looking forward to the introduction of the Japanese oyster. They brought over the seed from a number of different localities in Japan, in order to determine the most suitable variety. They found, as had been anticipated, that the seed oysters from the northern section of Japan, where the waters were of relatively the same temperature as the waters of Puget Sound, was the most satisfactory. Finding that these oysters grew and attained a good size, a large quantity of seed oysters from Japan were planted in the bay. The company encountered several difficulties. At that time there was a violent antipathy to the Japanese in this section and anything that was labelled "Japanese" could not be successfully sold in markets or resturants. Not only did they experience difficulty in establishing a market, but the company was handicapped by lack of capital, owing to the years of experimental work and to the purchase of land, and no banks would aid them financially. Also, the

state passed an anti-alien land law, which prohibited the holding of land by Japanese. So they sold out to an American company, which during the last three years has developed an important industry in our waters. Last year they sold $28,000 worth of oysters, which now are no longer called Japanese but Rockpoint oysters.

The technique of operation is quite simple. The original shipments from Japan came on brush, bamboo or pine. Most of the shipments now come on shell. When set out the oysters mature very rapidly and are marketable in two years. In fact, if they are left longer than two years they become so large that they are unsuited for the market.

Until recently there has been no indication of the spawning of these oysters in our waters, but during the present summer at Oyster Bay I found young Japanese oysters scattered all over the bay. If extensive spawning develops it will mean a complete metamorphosis of our oyster industry. I am of the opinion that in the Nasel River where recent plantings have been made that the oyster will spawn next year or the year following, and it is hoped that they will set over the flats where they grow so successfully.

MR. LECOMPTE: How are the rights obtained for the operation of the oyster beds.

PROFESSOR KINCAID: Originally you could take oysters anywhere, but later the state set aside certain restricted areas in which the State Department of Fisheries had the power to determine when, where, and how oysters should be removed for the purpose of planting barren areas. Other areas planted as oyster lands are held under private ownership. Another class of land, tide lands, which have been acquired by the oyster men ostensibly for other purposes, comprise some of the best oyster areas.

MR. LECOMPTE: Are they owned by individuals?

PROFESSOR KINCAID: Yes, they are purchased from the state. Practically all oysters now are grown upon privately owned land. Some areas are leased by the state. The Nasel River region is rented by an oyster company at a nominal rental of twenty-five cents an acre.

MR. LECOMPTE: Is there any open or closed season?

PROFESSOR KINCAID: No, there is an open season the year round The Rockpoint people market oysters through the summer.

MR. LECOMPTE: Does the flavor vary in the different species?

PROFESSOR KINCAID: The eastern oyster and the native oyster differ greatly. The native oyster has a coppery flavor which is quite different of that of the eastern oyster.

MR. TITCOMB (Connecticut): I would like to ask if there is anything about the Japanese oyster which would lead you to recommend it for the Atlantic coast.

PROFESSOR KINCAID: I see no reason why it could not be grown on the Atlantic coast. The Japanese oyster will grow on areas on which the eastern oyster will not grow at all. In Japan, where they grow on bamboo poles; at low tide you can walk through the beds and pick the oysters off the branches at the level of your shoulder, just as you would pick berries. When I first saw one of these oyster beds I could hardly believe it was an oyster farm; it looked more like a vineyard. I would not be surprised, therefore, to find that the Japanese oyster would grow in the east on areas where the eastern oyster probably would not succeed.

MR. TITCOMB: Do you think if Japanese oysters were planted in our waters that enemies which would injure our own oysters might be introduced?

PROFESSOR KINCAID: You might very well do so. Fear of introducing enemies is one of the reasons why the industry has not developed more rapidly here. The oyster men in the Sound region have been apprehensive about the introduction of pests, and for that reason have discouraged planting in the lower Sound region. Of course natural and artificial propagation in our waters would avoid the danger of importing pests. Experiments in artificial propagation are now being conducted.

MR. LECOMPTE: What method is used in shipping the Japanese oyster?

PROFESSOR KINCAID: They are brought across from Japan on branches and shells, and are set out in specially prepared places. The oysters are placed in boxes, containing four cubic feet, just before the ship sails. The boxes are stacked on the forward hatches of the ship and covered with tarpaulins. It takes twelve days to come across the Pacific and when they arive they are in perfect condition. All sorts of stuff is imported with them,—flat worms, tape worms, crabs, sponges, etc. They are shipped in March and the vessels travel along the great northern circle route where the temperature is 40° F., so that no refrigeration is required. Shipment costs only about $7 a ton.

MR. QUINN: I wanted to ask Professor Kincaid what devices are used for removing the commercial oysters from the flats.

PROFESSOR KINCAID: Gathering the native oysters is entirely hand work. The flats are completely uncovered at low tide and you can rake up the oysters without any trouble. No dredges are used and they employ tongs very little, except at times in getting oysters on a medium tide; but ordinarily they take them up very rapidly by hand—this, of course, is the native oyster. None of the oyster companies in the Sound region even own such a thing as an oyster dredge.

MR. QUINN: Do you have a law which requires the culling of oysters?

PROFESSOR KINCAID: No.

MR. POLLOCK (Washington): We have state sanitary inspection for certification.

MR. N. B. SCHOFIELD (California): Would the Japanese oyster be suitable to California waters, where we have a high salinity?

PROFESSOR KINCAID: Salinity would not be a detriment, because the Japanese oyster lives in water that is highly saline. I have no reason to believe that the oyster would fail in California, since apparently it will stand a wide range of conditions. It will stand high temperature and freezing.

MR. GRAY (Washington): Do you suppose the Coos Bay and Yaquina Bay districts in Oregon would be suitable for the Japanese oyster? There was once an abundance of native oysters, but owing to lack of conservation measures they have been exteminated.

PROFESSOR KINCAID: I see no reason why they should not succeed. They can grow, I think, wherever the native oyster has existed.

# THE WORK OF THE INTERNATIONAL FISHERIES COMMISSION UPON THE HALIBUT

By Will F. Thompson

*Director of Investigations, I. F. C.*

The problem of saving a great marine fishery in a condition of rapid depletion should be interesting to all fisheries men but to render it concrete enough for ready understanding, it is necessary to give a short resume of the natural history of the species in question.

Life History—The halibut is the largest of the flounder group with both its eyes on one side, in this case the right. It reaches occasionally a weight of over 400 pounds but averages between 15 and 20. Although an active swimmer it lives on the bottom. The fishery is carried on with long set lines laid on the bottom in all depths down to 150 or even 300 fathoms. It is not uniform in distribution, the halibut seeming to favor certain banks and certain localities on these banks. The older fish are found in the deeper water and these large fish collect into dense schools in the fall to lay their eggs.

The International Fisheries Commission has found halibut eggs floating in midwater over the spawning grounds from December to March. The eggs are the largest of pelagic ova, averaging about three and one-half millimeters in diameter. They float freely in the water and are distributed widely between the bottom and the top. As they develop, they are carried far and wide by the currents. With silk nets they have been taken over the great depths of the ocean, where they could not possibly survive if they should drop to the bottom as young fish. These eggs, developing slowly, become translucent larval fish with the eyes on two sides. These larvae have been taken in the Commission's nets both inshore and far out to sea.

The larvae, judging by the life history of their cousins, the smaller and better known flat fishes, take considerable time for development. Perhaps two or three weeks are required for hatching and two or three months elapse before they begin to settle on the bottom. One of the eyes grows in a strange fashion towards the other and eventually the flat fish swims and lies on its side, the two eyes looking up

from a colored right side which contrasts with the white blind side. The Commission has not yet succeeded in finding the later stages of these transparent larvae, but it is sending an expedition to the North Pacific the coming winter partly for this purpose. Whether the young fish that are carried far out to sea descend as they develop, into depths in which they cannot exist is unknown. They are next recognized as young fish in the bays and bights of the Alaskan coast. As they grow they stay more or less at home, shifting to schools of their own size. The fishermen begin to take them at the age of five years, when the smallest weigh two or three pounds. The halibut continue to grow at a variable rate according to the bank on which they are found. Their ages are determined by the annual changes in growth recorded in the bones, particularly in the otolith or ear-stone in the head which has rings much like those of a tree. From these lines we learn that the young fish trebles its weight in three years to become a six pound fish. Then it doubles its weight in the next three years to become a twelve pound fish. It continues to increase in length at a continually slower rate until at the end of thirty-five years it reaches 150 to 200 pounds. It first spawns about its twelfth year, and undertakes migrations for the purpose of spawning unlike the stay-at-home immature fish.

The available ground for halibut on our long coast is not as great as one might expect. The bottom falls off rapidly sometimes within a mile or two to 500 or 1000 fathoms, at which depth the halibut does not live. The shallow continental shelf at times extends out as far as fifty or more miles. There are a few inclosed areas such as Hecate Strait and Cook Inlet but as a whole the halibut is confined to the long narrow strip of bottom along our coasts. Nevertheless of all fisheries, that of the halibut is most truly a deep sea fishery. The fisherman seeking the great flatfish go to the edges of the banks and to the most distant regions. The time was when the halibut fishery was concentrated fairly closely along the coast adjacent to the southern ports at the entrance to the Strait of Juan de Fuca. But the halibut has everywhere been subjected to a far too concentrated fishery, and the source of supply has receded farther from the home ports.

It is a pity that man cannot effectively increase the rate of survival. Each halibut lays as many as a million and a half eggs during a spawning season. As a result the ocean

waters contain vast numbers of floating larvae. No hatchery could carry the larvae beyond a stage at which it begins to take natural food and the numbers in such stages in nature is so vast, that hatchery production would be but a negligible percentage.

Unable to interfere, man finds himself faced with a serious problem in the regulation of the marine fisheries. Biologists have thrown little light upon the important question of possible yield. Yet, the ability of a species to withstand the high mortality resulting from adverse conditions would seems to be one of the great factors both in fisheries and in the biology of evolution. Periods of adversity occur constantly in nature, giving rise among the simpler animals to an uneven abundance of young from year to year. A species develops means of withstanding these periods of adversity. It is this power of recovery with which man is really concerned when it is a question of replenishing those species of fish which man's industry depletes. Yet no studies of evolution have been able to devise means of measuring this ability of a species to withstand the strain of heightened mortality. It is not difficult to understand why fisheries men still lack information of actual value when extensive biological study has failed to answer the question.

In the case of the Pacific halibut, the conditions are unusually clearly defined and the problem is far more capable of approach than with any other fish. A few red or black cod are brought in, but these do not interfere with studies or regulations. There is but one method of fishing, that with lines. The banks from which the fish come are strung narrowly along a great coast line so that each bank has a minimum contact with its neighbor. Finally, the natural environment is unspoiled by man. These simple and clearly defined conditions contrast strongly with old world fisheries where the fishermen catch a great many other varieties at the same time, where the relative attention paid to any species is modified in indeterminate ways by the desire for others, and where the species is drawn upon by a number of different methods constantly shifting and difficult to measure. And in such places as the North Sea, any individual bank is surrounded on all sides by other banks, and problems of migration are complex.

In the study of the halibut fishery, we are fortunate again in that the problem of regulation is in the hands of two governments, instead of many between whom the interna-

tional rivalries are intense. As a matter of fact, international control for the Pacific halibut fishery already exists, whereas it is indeed difficult to believe that it will ever come to pass on the coast of Europe. Accordingly, the International Fisheries Commission, charged by the treaty of October, 1924 with the investigation of the halibut fishery and the formation of suitable regulations, has an unparalleled opportunity to contribute to the solution of one of the most important problems facing the fisheries of the world, that of possible yield. It has an importance out of proportion to the immediate financial returns which may be derived from rebuilding the halibut fishery.

Approximately seven millions of dollars are received annually by the Pacific Coast halibut fishermen, in return for a catch of fifty million pounds or about sixty per cent of the world's catch of halibut. This great fishery is relatively new. It began with the inauguration of steam transportation across the continent. With the completion of the Northern Pacific railroad, the first carloads of halibut were shipped through Tacoma to eastern markets. The statistics kept by the two governments although not perfect are nevertheless sufficient to show that the fishery grew rapidly from 1888 to 1910 and since then it has fluctuated around fifty-five million pounds annually. The enormous increase in the amount of gear has aroused considerable apprehension. In 1888 the fish came from Cape Flattery; in 1910 the vessels were exploiting southeastern Alaska; in 1913 and 1914, the banks on the eastern side of the Gulf of Alaska first received concentrated attention; in 1923 to 1924 the banks along the western side of the Gulf were first fished in earnest; and now, vessels are going as far as the entrance to the Bering Sea.

Men who do not realize the rapid change in fishing methods, maintain that the fishery is in a healthy condition. Because the halibut fishery has not become utterly exhausted in forty years during eighteen of which it has been a really great fishery, they believe that the fishery will continue to exist as a great fishery. They overlook the fact that the period of severe fishery does not equal the normal life span of an individual fish. Moreover, the variability from year to year deceives men as to the general trend. It is only by considering a period of ten or twelve years that a relatively rapid decline becomes apparent. The importance of scientific investigations of statistical records is therefore

very great. Only by adequate records can the actual condition of affairs be brought to light. Only by some means exceeding the power of human memory can the necessary scientific facts be demonstrated.

The International Fisheries Commission has appreciated the importance of such records and has gathered them from all available sources. Many fishermen have kept splendid records, sufficient to give a representative selection for investigation. The investigators of the Commission have searched through the musty lockers of many vessels, and through the store rooms of fish firms. They have found records kept as invaluable secrets by the older captains, and they have made inquiry trip by trip of current landings. The volume of information gathered is enormous, particularly for the later years, covering at times as much as sixty per cent of the total annual landings of the fleet.

To understand this work, it must be remembered that the fishermen used a ground line upon which hooks are placed at certain intervals. The Commission has taken into account variation in length of line and number of hooks and has discounted the change in gear for each unit. The yield per skate thus standardized has fallen in twenty years from three hundred pounds at each setting to forty-five pounds. On the older banks the fall has been at a relatively even rate. It is taking place also upon the newer banks, for instance, Portlock bank on the western side of the Gulf of Alaska, where the fall has been from one hundred thirty pounds to seventy-five pounds per skate in the last five years. The total yield from the older banks has fallen to 35 per cent of the 1906 production but the effort made to obtain that amount has increased two and one-half times and the decline is still going on. A still further decline seems inevitable and a great fishery is on its way to a minor position among the fisheries of this coast.

There is some evidence that the halibut fishery is increasing its resistance to the strain. On the old banks south of Dixon Entrance, the total yield has fallen to 35 per cent of its original amount, but the fall in actual abundance has been to 16 per cent. In other words, the present smaller total stock is bearing a greater proportionate strain.

In the early days of the halibut fishery the banks were so densely populated that the fish did not have a good

chance to survive, food did not suffice, and the older fish were actual enemies of the younger. Since the fish now are scattered sparsely over the banks, food should be more than sufficient and the younger ones should survive in far greater percentages. These young fish of rapid growth have come to comprise a larger percentage of the catch. It is not surprising then that the fishery should yield more in proportion to the number of fish. But whether this increased rate of replacement will suffice to maintain the supply is questionable. It has not in the past, for our statistics demonstrate a continuous decline.

The first problem which the Commission faces in regulation is to end the disastrous fall in abundance. It must find out by trial what yield the fishery is capable of without further reduction of the breeding stock. Once having secured a condition of stability, it faces another serious question. At present, the abundance is such that fifty pounds are taken each time a skate of gear is set. If by protective measures this abundance were doubled, would there be room on the banks for twice as many fish without reducing the rate of replacement, or without causing the amount of food to be inadequate? The Commission might advise a further step of increasing the abundance to twice or thrice this amount and the yield therefrom might also increase twice or thrice if the rate of replacement continued at its high level. The decision as to how far this rebuilding of the banks should go must mean the difference between a minor fishery and a great one. As yet no one knows where the rate of replacement begins to diminish with increasing abundance. It would seem folly to be content with a minor fishery when a great one could be rebuilt. Yet only by careful trial can the truth be known.

The essential unknown factor in the rate of replacement is the reaction of the halibut to changed conditions. If our surmise is true that the rate of replacement was at its maximum when the population on the banks was several times the present supply of halibut the fishery can be maintained at a higher level. There are two alternatives. In the first place the rate of replacement may still be increastained at a higher level than at present. There are two alternatives. In the first place the rate of replacement may still be increasing, and under intense fishing, whereby the actual abundance is lowered to a mere fraction of the present supply the yield will be equal to the catch which is

now obtained. The rapid decline in total catch tends to disprove this idea. The opposite view is that the rate of replacement was at its maximum very early in the fishery, that the first slight reduction in abundance started a draft upon the working capital, and each subsequent reduction has continued this draft. In the latter case, the halibut fishery would not persist as a great fishery and its maximum yield would be obtained under a much less intense fishery than now exists. The continuance of an intense fishery would mean the reduction of the working capital and its concentration in a few areas so that the halibut fishery would be doomed to a minor position.

Not having at hand the biological facts, the International Fisheries Commission cannot definitely evaluate the rate of replacement of the halibut under different conditions. The amount of strain which the species can stand permanently must be settled by trial. From the consideration of the past of this great fishery the necessity of restrictive measures to increase the breeding stock is indicated. The direction in which regulation must act is obvious, but how far it should go is the question. On the answer depends the existence of the halibut fishery as a truly great industry.

Faced with the necessity of recommending this course of action, the International Fisheries Commission must further point out to the administrator and the legislator the means with which they must work. Regulation can apply to any single area without special scientific knowledge, but the form of restriction depends on many conditions.

Such restriction was applied in the case of the present treaty by a closed season for three months. Upon examination of the facts, the Commission has concluded that this restriction is ineffective, largely because the fish supposedly protected are exposed to an intense fishery at another season, and whatever benefit has accrued simply serves to encourage the intensity of the fishery at other times. This regulation failed to take into account the migration of the halibut and to realize the simple economic law which dictates an increased intensity wherever the returns are greater. In formulating its recommendations, the Commission is faced first of all with the necessity of determining the degree and extent of migration. It is of little avail to impose restrictions on one bank when the beneficial effects are rendered negligible by the unrestricted catching of the same fish on another bank.

The reproductive season, the productivity of different sized fish and the drift of eggs and larvae, also influence the nature of the regulation. The biologist must discover the conditions which govern the rate of replacement, by answering certain questions. Are the younger fish gathered together in dense populations so that the rate of replacement does not rise as it should when the adult fish are reduced in numbers, and consequently must some of the strain of the fishery be shifted to these young? What are the schooling habits of the halibut? Do they tend to gather in dense groups even when few in number? The Commission has not answered all these questions, but it has acquired sufficient biological and statistical information to enable it to indicate unmistakably the necessity for regulation by individual areas, because of the relative lack of movement among fish, especially the young and it is able to outline the first rough restrictions, which must be revised, made more productive and less crudely burdensome as our knowledge increases.

After the type of restriction is once outlined, the Commission faces another scientific duty. It must outline methods of observation, an indispensable procedure in any scientifically conducted project. By these methods of observation, the Commission must be able to gauge the abundance of the halibut, the total yield and the effort required to obtain that yield. It must provide means whereby the results of its recommendations, or the results of regulations other than its recommendations, may be measured. Complete and comprehensive statistics are necessary to any intelligent handling of the fisheries and must include the effort involved, the time and place of the fishing trial and the yield. These records are the same as those by which we have demonstrated the present condition of the banks, which has only been possible because in past years the provincial government of British Columbia was far sighted enough to investigate and to preserve these records. Even so the early records are crude and apply but to a part of the hauls. It is only since the present Commission has existed that they have become more adequate. The system of observation in its fundamentals is already in operation. Perhaps it may be judicially strengthened and rendered more complete. If regulations are adopted, they will be futile unless their results are judged and corrected by statistical analysis.

It will be seen from the foregoing discussion that the actual rebuilding of the great deep sea fishery for the halibut is a matter for the administrator and the legislator, acting along lines indicated by the biologist. There is no magic formula whereby the yield can be perpetuated and increased without effort. Long and hard work is necessary to produce the facts upon which rational regulation can be based. We must render these facts available, must make the logic of our advice unassailable and through the passage of the years must convince the administrator and the legislator of the inevitable nature of our proposals. Methods of regulation must be devised for each step and methods of adequate and complete observation must be kept. For the rest, the administrator must have freedom to act. Upon him lies the burden of taking the initiative. There is no defined path for him to follow, he must make his own way with the biologist to advise and the statistician to record the results of his work. There is simply a sign pointing into the wilderness, a path of increasing reward if intelligent control is used, a path of failure and futility if action is blind and made just for the sake of doing something. Regulation of the halibut fisheries is not an act, it is a course of action.

*Discussion*

MR. LAIRD (New York): I would like to ask if there is any attempt made to hatch the halibut artificially as they do the eastern flounder.

MR. THOMPSON: The expense and difficulty of hatching in sufficient quantities to form a measureable percentage of the total number of halibut would render it out of the question. I do not believe you could carry the young beyond the hatching stage, since food is something which they cannot provide.

MR. LAIRD: At Woods Hole, Massachusetts, they have hatched flounders for years. They plant the young fish as soon as hatched, and they depend on the copepods and other marine organisms to feed them.

# PERPETUATING OUR HERRING—BY CONSERVATION

By Arthur S. Einarsen

*Division of Fisheries, Seattle, Washington.*

For a considerable time past there has been the impression that our local herring (*Clupea pallasii*) has reached such a low ebb in quantity that it was of no commercial importance in Puget Sound. As the more easily taken are of a small size there has been no demand for the market, and except as bait no interest in them has been shown. At least a decade past certain areas were set aside as Herring Preserves by the State Fisheries Department. These preserves which were to be located on spawning grounds have been very productive although a few have failed entirely in their purpose due to unfortunate choice of areas as spawning beds. This productiveness coupled with spasmodic fishing in some areas has resulted in a very heavy run in all spawning areas over the past three seasons. As bait herring are sold only in limited quantities, the run has not developed any great financial return.

The average yearly take in this district runs about 2,000,000 lbs. or 10,000 barrels. The price per 200 lb. barrels paid to the fishermen ranges between 2 and 4 dollars, which is not a very high return.

The herring season for the past three years has been watched closely to establish certain vital points to guide the Fisheries Department in the future with reference to the regulation of gear. This paper is not intended to be a scientific treatise but rather to furnish working knowledge which is so necessary for consistent and efficient progress in conservation.

The Herring Areas of Puget Sound. Our local herring (*Clupea pallasii*) are found scattered all over Puget Sound although they are not taken farther up Sound than Gig Harbor in any quantities. The bulk of the spawning run are found in Washington Harbor, Discovery Bay, Port Hadlock, Jackson Cove, Poulsbo Harbor, Gig Harbor, Hales Pass, East Sound, Birch Bay, Reid Harbor, Waldron Island, and Mosquito Pass. At all these places herring are taken, but the bulk are taken at Hales Pass, Holmes Harbor, Birch Bay, Poulsbo, and Discovery Bay. All these areas are spawning beds and the fish are used primarily for bait, although a few are absorbed by the fresh fish trade. The period of runs in the various districts does not occur at the same time, although some runs

overlap each other, and it is safe to say that herring are available here in one district or another from October 15th to June 25th of each year.

FISHING GEAR. Herring are taken in our waters by means of purse seines, beach seines, brush weirs or traps. The annual number of licenses issued to all these types of gear seldom runs over fifty with considerable variation in numbers from year to year.

The seines operate only in shallow waters seldom having a depth greater than 30 feet and incertain locatities where the herring do not approach the beach close enough to permit shore fishing, the purse seine is resorted to. Its depth is very little greater if any, but it has the advantage of being workable regardless of the depth of the water.

The herring weirs are constructed much along the style of the eastern bush weirs, however, in recent years the tendency has been to use wire instead of all brush, although brush is added to give the herring a suitable place to deposit their spawn. It is the practice to hold the herring for long periods in the weirs so that usually all spawning fish deposit their eggs before being marketed, therefore, each weir becomes an artificial hatchery.

REGULATIONS. The taking of herring is limited to seines not longer than 350 feet with a mesh not smaller than 1¼ inches. The laws of Washington also provide for a weekly closed season which varies from 36 to 58 hours, depending on the district.

A regulation made in recent years which is unique and should go far toward perpetuating the herring on Puget Sound provides for the division of the district into two areas. Fishing is permitted in each district only on alternate years. In this way no one area can be fished continuously with the result that the runs can be annihilated before it is observed. Should the yearly run during the open year in either district appear to be diminishing at a dangerous rate, further restrictions can be made and it hardly seems likely that the race can be wiped out before remedial measures can be inaugurated. Fortuately the district is comparatively small and practically all operators are not inconvenienced to any degree by the regulation since they have mobile equipment and maintain weir locations in both areas.

From an economic standpoint the regulation is practical since it places outlying fishing locations on a parity with those

situated nearer the market. For example; Holmes Harbor was exhausted due to heavy yearly fishing, while other prolific areas were overlooked entirely simply because distance made them less available. The division of the district by means of the new regulation has been made to take care of this particular point. It has resulted also in a more stable price being fixed on the herring.

FOOD. The sea water is teeming with life and during certain seasons of the year particular types predominate. The bulk of the herring food consists of schizopods of which there are several species, although fishermen are concerned chiefly with two species; one red in color and the other white. As both species decompose very rapidly and taint market fish, it is a customary practise to impound herring and allow them to digest all the food in the alimentary tract before preparing them for market. Otherwise the pack is a very inferior one. As little local herring is consumed as food the fishermen are not concerned with the quality of the fish and impound them only as an aid to having a ready supply on hand to bait up the halibut boats as they put in their appearance. It is assumed that herring like other fishes abstain from feeding heavily when the spawning season is near at hand, as they are usually quite poor and as spawning progresses they take on an emaciated appearance. This is particularly true in the Discovery Bay district.

The schizopod which forms the bulk of herring food is visible with the naked eye but the outline of an individual animal is not clear unless a low powered microscope or lens is used. They are found in tremendous schools, often covering the sea so closely that they impart a reddish tinge to the water, or, if of the white species, giving the water a milky appearance. There is an abundance of this food available in Puget Sound and the area should, therefore, be a natural habitat of herring provided reproduction conditions are satisfactory.

REPRODUCTION. In every area where spawning herring are found we also find an abundance of eel grass. There are no records of spawning herring in the locality where this grass is lacking. The "runs" appear at the spawning areas with considerable yearly regularity. The time of appearance is influenced to a considerable extent by the moon. Their actual appearance on a spawning bed in my experience rarely occurs on the wane of the moon, but as the moon begins to wax they will appear and gradually increase in number until the peak

of run is reached between the first quarter and the full moon. Spawning then is very heavy and as soon as the moon becomes full, spawning ceases and no new fish arrive.

When spawning in a natural situation the herring quickly cover each blade of eel grass to a depth of an inch or more. The procedure is not by pairing but consists of group activity. The water is permeated with the male sperms and the females choose a suitable grass blade or twig upon which to deposit her eggs. They are immediately fertilized and so effectively that it is safe to say that there is practically no loss. One sterile egg in 500,000 being the common average in this district. Sterile eggs take on a yellowish tinge and are easily visible to the eye. Herring eggs are 1/25 of an inch in diameter and our Discovery Bay fish each produce 20,000 eggs. As they are practically all fertile and the period of incubation is very short with little danger of extermination except by the depredations of feeding birds and fishes, the resultant big schools of herring are easily explained.

Herring eggs when fertilized can be distinguished from infertile eggs by the appearance of an embryo in a comparatively short time. This develops very rapidly and unlike the salmonoid fishes, the embryo is coiled at least once in the egg; the head and tail over-lapping. The eyes are not clearly visible until the tenth or twelth day and then suddenly appear. The actual hatching from that point on is very rapid, several days seeing the majority of the eggs hatched, although where successive layers of eggs have been deposited at different times the hatch is practically continuous. The fry that emerges from the egg is at least 3-8 of an inch long and has a very small yolk sac. The fish is snow white with the exception of jet black eyes. In a day or two the fish doubles its length and a darker color starts to creep over it. Opportunity to study the individual fish further was lacking so the history beyond this point cannot be described.

NATURAL ENEMIES OF SPAWNING HERRING. There is no mortality among the mature herring on the spawning beds except through the gulls, ducks and fishes. The gulls take considerable numbers as also do the cod and salmon, but the greatest loss is the result of gulls and ducks feeding on the spawn. At Discovery Bay during the 1927 season easily 20,000 sea birds, including five species of gulls, one species of tern, five species of ducks and four species of grebes were continuously feeding on spawn. Fortunately they chose the more

readily available eggs and as a result most of the eggs exposed by low tide and a little below that were eaten up before they could hatch, while the lower masses of eggs were practically unmolested. As the spawn is several inches deep and covers acres of area, the loss by the depredation of birds is considerable.

THE EFFECT OF BRUSH WEIRS ON SPAWNING CONDITIONS. The effect of brush weirs on spawning conditions was closely studied to established their practicability. Piles and small mesh, galvanized wire forms the impounded area in a weir. The brush is added and attached to the wire and piles to provide a suitable spawning foundation for the herring. This type of construction is a degression from the original brush weir which was actually constructed of brush. The best feature of the brush weir at the time they were originated was the economy of construction; no material being necessary but brush and by diligence a very satisfactory weir could be constructed. With the increased cost of labor the construction of a weir entirely of brush except in a few ideal, isolated cases would be prohibitive and as a result wire netting and piling have been substituted. The brush is added to make at least an attempt to conform to the license and to some extent is just as effective as a depository for spawn as a brush weir. The effectiveness is in direct proportion to the amount of brush submerged for spawn to collect on.

It was discovered that most of the eggs deposited above low water range on brush weirs were destroyed before they could hatch. This was due to two causes: (1) They were easily accessible at all times to sea birds, as the gulls could feed on them when they were exposed and if submerged they were easier for the diving birds to reach than eggs deposited at a lower level: (2) The drying effect of the wind and sun caused almost a total loss of eggs. Eggs which were easily recognized as fertile soon took on an appearance of dormancy with little or no change in the embryo and in a few days putrefaction set in. The mass of eggs often two or three inches deep and covering the whole weir, being deposited both on the wire web and brush would become loosened and sink to the bottom where it would lie in a foul mass and decay.

In a district where spawning herring periodically resort the use of brush weirs to take the mature fish is undoubtedly a benefit to the runs if certain precautions are taken.

The brush used should be all placed below water so that it is submerged at all times. All brush should be placed on the

inside of the impounding area as, (1) the impounded herring are anxious to deposit their spawn, (2) the natural spawning area on the eel grass on the bottom is not sufficient, and (3) the depredation of sea birds is far less on the inside of the weir than on the outside. With a little diligence a brush weir operator can reduce the depredations inside the weir to a minimum.

As runs occur in spawning areas several times during a season, new brush added after each spawning will increase the available area for later runs.

The essence of perpetuation is the conservation of our natural heritages. There is no economy in allowing a useful species to go the way of the Great Auk or the Passenger Pigeon.

*Discussion*

DR. C. M. FRAZER (Vancouver): I am much interested in this paper which has been given by Mr. Einarsen, particularly because I did some work on this species some years ago in the Nanaimo region, and the conclusions I arrived at in a number of instances are rather different from those for Puget Sound. Perhaps I may be allowed to refer to a few of those instances.

In my experience the term "spawning beds" cannot be used for herring in the same sense that it can be used for salmon. The herring do not always go back to the same area to spawn year after year. I examined herring spawning areas for perhaps a dozen of years in succession over a large territory around Nanaimo, and found very definitely that in some years the area in which the spawning took place was different than in other years. There was a certain amount of overlapping, but apparently there was no definite spawning ground for any particular series of fish.

In regard to the emaciation during the spawning time, I have watched herring during the spawning season year after year; I have rowed over them in a boat at the time they were spawning and I have found that they did not stop feeding. In the Nanaimo region they do not restrict themselves to the eel grass areas, but spawn over various algae, mostly fucus. They spawn at high tide, so that the eggs are exposed at low tide, and they are subject to destruction by ducks and gulls, but they are not ruined to any great extent by drying. In the Strait of Georgia region the tides are a little different than in the open sea. I do not know just how they differ from those in Puget Sound, but there is practically only one tide in a day that can be considered a low tide. In the spring these tides come nearly all in the night or towards evening, and the eggs do not dry out in the great majority of cases. I have gone

over areas that were exposed at low tide for as much as five, ten, or fifteen miles, and have seen scarcely any dried eggs.

My paper published in the Transactions of the Royal Canadian Institute about 1914 gives data in regard to the development of the herring egg. The herring is very easy to follow from an embryological standpoint, because the egg membrane is transparent and it is possible to observe most of the stages without doing sectioning. In a period of one to four days, in the great majority of cases, all the organs were definitely formed. In an average of a little over two weeks, varying from 12 to 20 days but mostly from 14 to 16 days, they hatch, and in about four days more the yolk is absorbed. At that time and for some time afterwards they are carried by currents so that not infrequently they appear in very large masses, with the result that other fish can readily prey on them.

As to the number of eggs found around Nanaimo, 35,000 was the greatest number found per fish and only in seven or eight year old herring. They apparently start to spawn at the completion of the third or fourth year. They start with about 10,000 eggs and the number increases until in the sixth and seventh year they have about 35,000.

MR. EINARSEN: I have approached this matter from the standpoint of our own conservation program. We have gone over the herring areas, and it is well known that they resort to these districts from year to year. I do not maintain that the herring will resort to these particular limited areas from year to year, but the purpose of the preserve was to maintain them in the district where it is known that they would spawn.

Now, in regard to "feeding," you will remember I qualified my statement by saying, "It is assumed" that their emaciated appearances is due possibly to lack of food. I did not have the opportunity to study that particular problem and my statement is simply an assumption and I hope it is accepted in that spirit.

# PRELIMINARY STUDIES ON THE CALIFORNIA STRIPED BASS

By E. C. Scofield,

*Fish and Game Commission, California*

In an effort to detect depletion among the striped bass and to avert such a condition should it ever occur, the California Division of Fish and Game has undertaken a systematic scientific study of that species. First of importance in such a study is a measurement of the relative abundance of the species. With a knowledge of their abundance year after year it is then possible to detect an increase or a decrease. If, in the future, a serious decrease in abundance occurs, which may be the result of overfishing, it will only be with the knowledge of their life history that proper legislation can be enacted and the striped bass saved from a possible extermination. This, then, forms the second important work in a scientific study of the species. Let me state those two important divisions of a fisheries investigation once more. First, a study involving a measure of the relative abundance of the species, and, second, a study of the life history involving age, rate of growth, and age of maturity. The former of these is to detect a decrease in abundance, and the latter is to ascertain the cause of the decrease that it may be remedied if due to overfishing rather than to a natural fluctuation.

Work on the life history of the California striped bass was begun in 1925 and is now being brought to a close. Much of my material is yet to be worked up, therefore my present talk is to be on what facts I have to date.

The Age of Striped Bass: Fortunately the scales have been readable and have been used for age determination. Scales have been removed from every part of the body and all have been found to be consistent in their annulus formation. However, the scales from the central part of the body above the lateral line are the clearest and have been used entirely in this investigation.

To make certain that my age readings have been correct I have made a triple check on my work. The first check consisted of aging the opercles and otholyths apart from the scales. A later comparison of the three agings showed similar result. A second check was made from frequencies of seine-caught material. The size bass occuring in any of

the year modes compare favorably with age sizes as a result of age determination by scales. My third check consisted of separating all the striped bass of a certain seine haul into their various age classes. A frequency curve was then made of each of these age classes. Each was then favorably compared to the original length frequency curve formed from the original material without regard to age. I might add that aside from these three checks I have re-aged my material at various intervals without knowledge of my former readings. As in most species I have occasionally found peculiar scales which varied considerably from the average. In such cases, which amounts to less than 4% I have ommitted these scales in the belief that there may have been an error committed at the time the material was gathered.

Individual scales vary a great deal in their appearance, so I believe it well to discuss something of their make-up. Normal growth appears on the scale as evenly spaced, arched circuli, lying between the numerous radii. At anytime between March and May the circulus lying at the extreme edge of the scale will form in a straight line instead of the usual arch shape. The younger and immature bass will usually lay down one such straight line, but the larger and mature bass will lay down from three to seven. Immediately after the last straight circulus is formed normal growth will resume. Such an operation is the formation of the annual check by which the age of the fish is determined. Unlike most species there is not a long period of retarded growth, for prior to and immediately after the formation of the actual check, the growth as recorded by the circuli is perfectly even and normal. A small distinct check composed of one of the circulus is formed on scales of young bass because they are feeding considerably at the time. Among the older bass, however, spawning is underway at the time the check is forming, and their diet has lightened considerably. These two combined events tend to retard their growth a great deal longer, thus the annual check is much larger.

RATE OF GROWTH: The striped bass, like most other species, grows rapidly during its early life. Growth based on actual average measurements during the first seven years are as follows:—One year-10 centimeters, two years-25 cm., third year-36 cm., fourth year-42 cm., fifth year-50 cm., sixth year-55 cm., seventh year sixty-one cm. By its

fifth year it has reached the commercial size of twenty inches. By its eighth year it has grown too large to be caught in the commonly used five and one half inch gill nets. (A minimum of 5½ inch mesh gill nets is required by law, and is resorted to exclusively.) The big drain, therefore, on the commercial striped bass is on the five and six year classes. After the eigth year there occurs an average yearly growth of approximately five centimeters. Large bass among the commercial catch are scarce owing to the type of gear employed, therefore my growth estimates above the eight year group is based on very few individuals.

The major portion of the yearly growth occurs during the spring and summer months. During winter, growth is practically at a standstill. Among the younger and immature bass the rapid spring and summer growth commences directly after the annual check is formed. Growth among the larger and mature bass is delayed until after the close of the spawning season, or approximately July.

Facts relating to the rate of growth have been obtained by the application of length frequencies from monthly samples, and by actual measurements of aged material.

AGE OF MATURITY: The age of maturity is one of the most vital subjects in this fisheries investigation. It is essential that we know what portion of spawning bass, if any, is now being protected from the commercial catch. A knowledge of this question will render it possible to determine if the bass are being caught at a faster rate than they are being reproduced, or if possible decrease in the relative abundance is due to overfishing or to a natural fluctuation, such as has occured in many other fisheries. If the cause be due to overfishing then the knowledge of their age and size at spawning and their spawning area will make it possible to place definite restrictions on the fishery with assurance that the species will be amply protected.

Material for use in the determination of the age at maturity is at the present time still being gathered, and I will therefore be unable to state definite results. However, from a similar though less extensive work carried on during the spawning season of 1927, I have formed a few tentative conclusion which may be of interest. Among the four year female group a very small percent spawn, generally those individuals extremely large for their age. The majority of the females appear to mature and spawn for the first time in their fifth year. The actual percent of spawners

in this age group is not yet known though it is close to 75%. Practically 100% spawn during their sixth year and every year thereafter. Many males mature in their third year. The majority, however, spawn for the first time in their fourth year.

The material gathered in 1927 was too scanty to form definite results. The above, therefore, will be supplanted by a final report of the 1928 season which will contain an abundance of material and more definite results.

MIGRATIONS: At present I am unable to present actual facts pertaining to the migrations of the striped bass as no marking or tagging experiment has been performed to learn of their movements. The discussion I wish to offer is based on my own personal observations as well as those of old time sport and commercial fishermen.

In taking my monthly samples of bass I have always noticed the scarcity of the two and three year group within the San Francisco Bay. At first I believed the reason to be a selective gear used for obtaining the samples. Later, however, I thought that there was a possibility of a seaward migration during the second and third years. The reasons for my conclusions on this point are: the tremendous growth occuring in either of these two year groups most probably due to heavy feeding in the richly populated waters along our coast, the scarcity of these two groups within the bay, and their abundance along the southern coast and in adjacent rivers.

Movements of the bass within San Francisco Bay are to a large extent determined by the weather conditions and the food they seek. If the weather is calm and the water clear the bass will school up considerably and feed on other schools of smaller fishes. Heavy rains or winds will muddy the water and in this case they will not school. During the fine warmer months they prefer the extensive mud flats within the bay. Here food is plentiful and the water is warm, often 75 degrees F. The least wind will cause the waves to pound the banks and the bass will immediately retreat to deeper and quieter waters.

During the early spring months there is considerable movement among the bass. In the lower bay, close to the ocean, schools will quickly come and go. Net fishermen have fine luck in catching them for they are fat and very inactive. Anglers will cast in vain, but the stripers will not take the hook. The reason is that this body of fish

has practically ceased their feeding and are on their way to spawn up in brackish and fresh waters. The spawning area in San Francisco Bay is very general. Where the Sacramento and San Juaquin rivers unite to empty into the upper bay there is an area of a thousand or so square miles of very low and flat delta country. A net work of sloughs, some natural and some dredged, divide the entire region into islands. Many of these islands are below the water level and high waters occasionally break the levies and flood them. These flooded areas, sometimes as large as 3,000 acres, form the choice spawning grounds for the striped bass. Here the water temperature ranges from 67 to 73 degrees F. during the warmer months. The tides run very little, allowing the bottom to become muddy.

Besides these flooded areas there are blind sloughs, extensive mud flats, and swampy areas that also afford excellent spawning grounds. It is also very possible that a good many bass migrate many miles up the main rivers to spawn. Though I have not examined such bass I have accurate information as to their abundance at points 200 miles up the Sacramento River during the spawning time. It appears that bass will spawn in fresh water as well as brackish, for I have taken spawners from both localities.

The spawning run which begins about the middle of March has ceased by the end of July. After spawning they feed ravenously and in seeking food they spread in all directions. Most of the bass, however, return to the salt water where the food is more plentiful. Fishermen on the opening of the season, August 1st, have more success down in saltier water. They claim that most all the bass gill in the upper side of their nets, thus indicating that the fish are heading towards the lower bay and salt water.

FOOD: Random examination of stomachs over a period of three years has afforded definite facts relating to their feed. The assortment of food found in their stomachs leads me to believe that they will eat any food that occurs in such numbers that is easy to obtain. In San Francisco Bay we have an abundance of small fishes and other suitable foods for bass, such as shrimp, crabs, clams, periwinkles, sardines, anchoives, smelt, gobies, minnows and herring. These form the main diet of bass because of their continual presence in large numbers. Occasionally, in the early summer months the bass will feed on their own young.

Should salmon occur in large numbers as they once did in San Francisco Bay I believe that they would also be eaten by the striped bass. At the present time the salmon run is very meager, thus the migrating fry during the spring and fall are scarce. Their present scarcity is perhaps the reason that I have never removed one from the stomach of a bass.

*Discussion*

MR. TITCOMB (Connecticut): This is an extremely comprehensive and enlightening paper on the striped bass, a fish which is fast disappearing on the Atlantic coast.

MR. LECOMPTE (MARYLAND): Do you have a minimum and maximum size?

MR. SCOFIELD: A maximum size between March 1 and May 15 of ten pounds, and a minimum size of 20 inches at any time during the open season; that is, for the commercial catch.

MR. LECOMPTE: Do you have a closed season?

MR. SCOFIELD: Yes, we have closed seasons amounting to about six months out of the year—from May 15 to August 1 and September 17 to November 14.

MR. FASTEN: I believe you said that the male matures in the fall and that the female retains the spermatazoa for a considerable period over winter?

MR. SCOFIELD: I do not know whether or not the sexual elements of the male ripen too far in advance. The male seems to mature three or four months prior to the female.

MR. FASTEN: It is a very interesting problem. In some invertebrates the female retains the spermatazoa for a considerable period while the eggs are ripening and fertilization takes place a number of months afterwards.

MR. SCOFIELD: I do not think that is the case in the striped bass, because artificial propagation has been carried out to a considerable extent on our west coast, and fertilization takes place immediately on mixing the milt with the eggs.

MR. LECOMPTE: Have you ever tried propagation of the striped bass in captivity?

MR. SCOFIELD: Not personally.

MR. LECOMPTE: Has your state department done so?

MR. SCOFIELD: Yes.

MR. LECOMPTE: Without success?

MR. SCOFIELD: Without much success.

MR. GRAY (Washington): Since the early plantings of the striped bass in the Sacramento district they have gradually spread northward, and for the last three years there has been a good catch. There have been runs in Coos Bay, Oregon, of some commercial importance, and I have been informed recently that they have appeared in small numbers as far north as Puget Sound.

MR. SCOFIELD: On my way south to California I intend to visit some of the places along the coast frequented by bass as at Marshfield, Oregon. From the fact that they are being caught at the rate of a million pounds a year, not counting the anglers' catch, and in the last few years have been coming into Oregon, it would seem that the bass are rapidly availing themselves of the choice grounds.

# FISHERIES EDUCATION

By John N. Cobb, Dean

*College of Fisheries, University of Washington, Seattle.*

Probably the oldest industry in the world is that of fishing, and yet the world had to wait until 1897, when the Japanese started their first fishery school, before it had an institution of learning that covered all branches of the subject. And despite the fact that the Japanese thoroughly established that there was need for such an institution, they had no imitators until the University of Washington established its College of Fisheries early in the year 1919. Previous to 1897, and subsequent to that year, some so-called fishery schools had been established in various European countries, but a glance at their curricula shows plainly that the teaching of navigation was the principal purpose of most of them, while in others the study of fish culture was the purpose aimed at, and but few of them lasted long at either.

When the subject of teaching fisheries in our higher institutions of learning was first broached it was anticipated that those on or near the Atlantic seaboard would be the first to take it up, but such did not prove to be the case. Harvard and various other eastern universities and colleges gave the matter more or less consideration, but no definite conclusion had been arrived at when the University of Washington early in 1919 took definite official steps toward the establishment of a fisheries school.

The reason for the establishment of such a college on the Pacific Coast is patent to all who are familiar with our coast. Although the youngest section of our commonwealth, the Pacific Coast had rapidly forged to the front in population and development of resources during the years which had elapsed since California and Alaska had been acquired in 1845 and 1867 respectively, and in no particular was this more noticeable than in the economic development of our fisheries. From practically nothing they had been built up until by 1919 many thousands of persons were employed either directly or indirectly, millions of dollars were invested in plants, vessels, apparatus, etc., while the annual value of the products marketed (a large part of which were canned, salted, frozen or otherwise preserved), averaged around $70,000,000. In the preparation of such an enormous output of goods for distribution throughout the world, the need of many trained men was apparent to the most farsighted of our operators, and when at the or-

ganization of the Pacific Fisheries Society, at a meeting held on the campus of of the University of Washington in 1914, the matter of the establishment of a College of Fisheries was strongly advocated it met with favorable response from the operators and the University administration.

Unfortunately the breaking out of the world war a few months later, and our subsequent entrance into the same as a combatant, caused the temporary shelving of the proposition. The end of the war in 1918 caused a revival of the subject, and early in 1919 the board of Regents authorized the establishment of the institution, and I was elected as its first Director (later the title was changed to Dean).

The first classes were started in the spring quarter of 1919 in temporary quarters in Commerce Hall. Shortly thereafter the buildings which had been erected on the campus for the training of recruits in the U. S. Naval Service were turned over to the University, and during the summer three of these were remodeled for the use of the new College.

From an enrollment of 13 in the spring quarter of 1919, the college has grown until at the opening of the winter quarter of 1927 there were enrolled 115 regular students. Since the opening 40 students have been graduated with the degree of Bachelor of Science in Fisheries, and five with the degree of Master of Science in Fisheries. In addition, a number of special students, mostly persons disabled as a result of the war services, have received from one to three years' training in fisheries, while a very large number have attended the annual short courses given during the winters. While the bulk of the students have come from the United States, and mainly from Washington, a considerable number have come from foreign countries or our outlying possessions, including the Philippine Islands, Japan, Siberia, Russia, Palestine, England, Canada, Norway and Finland.

About 1922 the Massachusetts Institute of Technology established a course in Fisheries Engineering, but I understand but few students have taken advantage of it. In the autumn of 1927, Dalhousie University, in Halifax, Canada, started a course in fisheries which is intended ultimately, if successful, to cover all branches of the science. A number of other institutions have had the matter of the offering of fisheries instruction under consideration since 1919, but for various reasons have done nothing as yet.

EDUCATIONAL WORK. From the very beginning every effort has been put forth by the faculty of the college to teach the

latest and best methods, and that this has been appreciated is officially attested by the fact that the Philippine Bureau of Fisheries, the fisheries department of the Province of Quebec, and the government of Palestine have all sent men here to be trained in fishery science, while the government of Brazil has asked for the same privilege. The college is too young and the number of its graduates too few as yet to have had very great influence on the scientific development of our fisheries, but these graduates have so rapidly forged to the front in all lines that even now their influence is being felt.

The need of the industry for scientifically trained men is obvious to all in this enlightened age. In earlier years, however, such men were not available and those who had laboriously worked out methods based solely upon experimentation, in most cases without knowing the why and wherefore of the results obtained, had to teach their successors. As a result we find the industry from top to bottom staffed, with a few notable exceptions, with these plant-trained workers. Many of these workers are bright men and have achieved a considerable measure of success despite their educational handicaps.

Of recent years the consuming trade has demanded better and safer food products and this has extended to all kinds of preserved fishery products. As a result federal, state and municipal authorities now demand that all food-preservation plants be conducted in a sanitary manner; that the raw material be handled in such a manner as to be free from danger of contamination until preserved; that the preservation methods be based upon the latest scientific principles and carried out along these lines, and that these preserved goods be so handled and transported as to safe-guard their purity. In order to do this the superintendent of a large food packing plant in these modern days should have at least a general knowledge of bacteriology, chemistry, fisheries (which is in the main here an application of the two first named) and engineering, while there should be a properly staffed laboratory to carry out the thousand and one experiments necessary in keeping the product up to its proper standard. The country that falls behind in this line will soon drop out of the economic running as its more highly trained competitors will far out-distance it.

In no branch of fisheries is the need of scientifically trained workers more obvious than in fish culture. This branch, dealing as it does with the restocking of our depleted waters; the development of as good, if not better, breeds of fish than previously inhabited our waters; the introduction of new

species from other sections of our own country or from abroad; the hatching, care and rearing of young fish in our hatcheries, including the onerous problem of the proper feeding of same; all cry loudly for scientifically trained men. Despite this great need but few scientifically trained men have ever gotten much, if any, hold in the industry, partly, I think, due to their own lack of effort, and partly to the meager remuneration offered. Even in the pioneer days of fish culture a few of our states drafted biologists into their service, either temporarily or permanently, and this practice has extended in recent years, until now a number of our state fish commissions either have a biologist permanently engaged or else call upon the biological departments of their local institutions of higher learning. The U. S. Bureau of Fisheries, under the progressive and able management of Mr. Henry O'Malley, has gone even further and has set aside a hatchery as a fish culture laboratory, while much valuable research work is being conducted by experts at various hatcheries as needed; this in addition to the regular scientific work of the Bureau.

When the College was started some people expressed doubts as to whether men scientifically trained in fisheries could find places in the industry. That their doubts were unfounded is shown by the fact that the 40 graduated students, practically all of them are now engaged profitably to themselves in some branch of the fisheries, while of the special students who received training a number have since made good in the industry. I would call attention here to the fact that the college does not, and never has contemplated, turning out men fitted only to be fishermen. All students are trained so that they will have a theoretical and practical knowledge of all branches of fisheries included in the course selected, together with some training in business and business law, in the expectation that such young men will advance more rapidly and be more profitable to their employers than similar young men without such preliminary training.

SHORT COURSES—As it was not feasible for most of those actively engaged in the industry to take the regular four-year course offered, it was decided to offer an annual series of short courses for these people. The first series was given in January and February of 1920, a period of 8 weeks, and these were continued annually until 1927, when they were abandoned, largely because by this time the number of regular students enrolled was so great that they absorbed the time of the small staff of instructors and taxed to the utmost the buildings and

equipment available for the college's use. The following list will give an idea of the scope of these short courses: Canning of fishery products, fundamentals of canning, canning machinery, curing of fishery products, methods of testing canned foods, bacteriology of foods, food laws, fish culture, ichthyology, fish diseases and parasites, elements of navigation, gas and oil engine practice, and first aid to injured. Every effort was made to have these simple, concise, practical, and understandable by a person who had no more than a grade school education. They were attended by a large number of owners, superintendents, and others engaged in the various branches of the industry, and by others who hoped to enter the industry. In the later years persons came from as far as England to the eastward and Japan to the westward, to take these courses. As our buildings are being greatly enlarged and our equipment much expanded just now, it is possible that these short courses may be resumed.

LABORATORY EQUIPMENT.—The college has the following laboratories: Ichthyology, Fish Diseases, Fishery Methods, Canning, Curing and Drying, Food Testing, and Research. These laboratories are all equipped with complete machinery and apparatus for giving practical instruction and for carrying on research work. For instance, the canning laboratory is equipped with its own steam plant, retorts, vacuum machines, double seamers, steam jacketed kettles, automatic controls, etc., for packing in either tin or glass containers.

There is also a fish hatchery with a capacity of 2,000,000 eggs of all varieties handled in such plants, and also a number of ponds for rearing fish. A running water and balanced aquaria are available for the study of aquarium management and the hatching and rearing of ornamental fish.

In addition there are in the immediate neighborhood all kinds of industrial and fish cultural plants being operated and these are all opened freely to our students and in which many work in their spare time.

RESEARCH WORK. While the teaching of fisheries science has been and is the principal work of the college, the various trained instructors are interested in different branches of the science and they, assisted by senior and graduate students, take up in addition to their teaching work various problems which confront the industry and endeavor to find solutions for same, and the results are published either in our own series of bulletins or in trade and scientific journals accessible to the

industry. Sometimes this research work has resulted in large direct financial gain to the industry, while in other instances the newer or better methods evolved have greatly aided the industry in turning out more, better, or cheaper products, or a combination of all three; this alone, in my opinion, more than justifying the establishment of such an institution.

As to the range of research work I might call attention to the fact that a beginning has been made of what is intended to be a comprehensive biological survey of the aquatic resources of our state, some three summers having already been devoted to it. The life histories of a number of important species have been worked out, while much has been done by Dr. John Guberlet, our pathologist, upon the diseases and parasites which wreak such havoc among the fishes in our hatcheries and to a lesser degree, in a wild state, and we have already published two bulletins giving the results of this work while others are ready for printing.

Considerable has been accomplished in our fish culture laboratory in solving a few of the many problems that beset the fish culturist. Extensive studies on the best and most economical foods for fish, the effects of trade wastes and other pollutions on aquatic life; the influence of various factors on salmon and trout, such as swift currents as an influence on development, hard and soft waters, etc., comprise some of the many problems investigated.

My own work for nearly seven years has been on the problem of safeguarding our runs of salmon, trout, etc., in streams which have been, or in which it is proposed to install dams for power, irrigation or domestic purposes, and a summary of part of the work appears in the 1927 Transactions of the Society.

Considerable scientific work has also been carried on in connection with the rearing of native, eastern and Japanese oysters.

As the canning of salmon is the greatest of our Pacific coast fishing industries (the annual value of the pack amounts to some $65,000,000) much of the college's research energies have been devoted to its many problems. While some of this work has been carried on wholly in its own laboratories, some very valuable work has also been done in collaboration with the Seattle branch of the National Canners' Association, and the joint results have been of immense value to the industry and are set forth in the numerous bulletins of the college, of the association, and in various scientific and economic journals of the world.

Investigations of the best methods for so preserving various of our commoner aquatic species but little utilized at present as to make them available in the markets of the world, have been carried on with some 30 species, and results of much value have been obtained with the following: Canned crab meat (published), preserved pickled herring (published), eulachon (in preparation), cultus, or blue cod, sablefish, canned clams and clam nectar, canned shrimps, salmon eggs for food and as bait, fish balls, sardines, canned herring, canned halibut, etc.

The college is ready at any time to carry out, so far as lies in its power, investigations in the preservation of food products that will conduce to the welfare of the state and nation. Methods for canning rabbits, chickens, pork and beans, chile con carne, noodles, noodles and chicken, reindeer meat, spaghetti, various fruits and vegetables, etc., have already been worked out for prospective operators. No charge is made except for the materials used in this work.

Its food testing laboratory annually handles hundreds of samples of food products submitted for testing as to the sufficiency of the process employed, and it is believed we are well within bounds in stating that this service has saved our food packers large sums each year in preventing spoiled products. No charge is made for this work.

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**University of Washington**

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**Volume I**

1 Preserved Pickled Herring. By Clarence Louis Anderson, Pp. 1-64, 1925.
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# HYDRO-ELECTRICITY AND SALMON FISHERIES

By W. J. Calderwood, I. S. O.; F. R. S. E.

*Inspector of Salmon Fisheries for Scotland.*

The very great increase in the supply of electricity produced by means of water power is bringing about a most serious menace to the future of salmon fisheries.

If there is one particular element which fish cannot do without, it is water, and, as the various species of salmon have to enter rivers and lakes in order to reproduce their species, they require fresh water.

It is unnecessary, to an American audience, to say anything about the general benefits of a reasonably cheap supply of electricity. There is no gainsaying the fact that great benefit results to the community, and it is equally true to say that the general interest is greater than the individual interests of those who may be injured by the building of high dams and the abstracting of great quantities of water. At the same time there seems to be no reason why this great industry of supplying hydro-electric power, should destroy an industry like salmon fishing which is absolutely dependant on water.

In Scotland, where schemes of great magnitude are now maturing, the promoters draw their plans without any special reference to other interests with which they may interfere, a bill is produced in Parliament, and a tribunal is appointed to inquire into the merits of the schemes and to adjudicate upon claims for injury, and adjust the proposals in the public interest.

The promoters are generally willing to pay money compensation to proprietors who prove injury, but this method of dealing with the problems which arise is of no use to the fishing interest, if unaccompanied by conditions for a beneficial use of the money, or by definite works, carried out by the promoters, for the purpose of mitigating the evils. Money compensation may indeed be worse than useless, so far as fisheries are concerned, for those who receive it may be those upon whom depend the calls for alternative works by the promoters, and money may be granted in lieu of all other claims.

Water compensation, on the other hand, is of the greatest possible benefit, as all subsidiary works which may be undertaken for the benefit of the fisheries require water. Without water, spawning tributaries are apt to run dry,

gravels be left uncovered and exposed to frost, fish are unable to ascend as formerly, healthy scouring action of floods is reduced, and, in our relatively small rivers of Scotland, the actual volume of water may be so lowered that important areas in a catchment basin may no longer be habitable by salmon.

Where salmon passes are possible at dams, they naturally discharge a certain amount of compensation water, and I shall refer to the subject of passes presently, but there is one method of securing compensation water which I regard as specially valuable and to which I should like to give prominence now.

It not infrequently happens that outside the limits of the scheme of water collection for electric power, there is a lake connected to a river system, possibly at a lower level than is attractive to the engineers. In Scotland we have many lakes among the hills of the regions where power schemes are planned.

It is perfectly reasonable to ask the promoters of schemes to undertake additional works in order to mitigate the difficulties they create in fishery interests. They are proposing to deprive the fisheries of an essential element. If then it is possible to select a lake where even a comparatively modest storage of water can be made, and to have the use of this water exclusively for the benefit of the fisheries, we have what, in my opinion, is the most valuable compensation. Under natural conditions, a great amount of water runs to waste at certain times of the year. If this can be held up for use when water is most needed, the result is most beneficial. I am not aware if this expedient has been resorted to in America where rivers are on such a grand scale, but with us in Scotland a fair number of the head streams which flow from lakes have been treated in this way. Experience has shown that when the rivers run low and fish are confined in certain pools for a considerable time, so that they become stale and are more or less useless for sport, an artificial rise of the river, even if it be only a few inches, moves the fish up to new reaches and brings them freely on the rise again. In the same way this expedient is most valuable if, through the abstraction of water, fish are quite unable to ascend natural obstructions. Also, in one or two of the schemes in Scotland, water is being taken away from its natural catchment basin and used in another. In one case, water which normally should flow to the east coast is being diverted to the west coast.

This is much more serious than if water is carried a certan distance down a valley and then returned to the river.

If a proposal includes the erection of a high dam in a gorge in the lower reaches of a river, the most serious and fatal difficulty is raised, since this is tantamount to closing the whole river to the ascent of salmon. There is one such proposition before us here at the present time, and I am urging that the only course in support of the fishery interests is to try to get this particular dam and power station withdrawn from the scheme. The water in the district referred to will already have passed through three power stations before coming to the station near the mouth of the river. The high sporting value, as well as the commercial value of coast netting stations dependent upon the stock of fish bred in the river, are, with other interests, sufficient to create a very high claim for total loss.

I may perhaps explain that we have salmon ascending our rivers as clean fish, in every month of the year, and that the early or spring run is the most highly prized for angling, since the fish are in splendid condition and give excellent sport. But those early fish enter fresh waters when the temperature is low, and if they meet rough broken water at any obstruction, they do not attempt to ascend further, till the water has lost its wintry condition. On this account, a low fall or weir is sufficient to stop them till, usually about the third week of May, with a suitable rise, or a suitable fall of level, they begin to leap. They never leap through rough water in the early months of the year when the water is cold. At times they may ascend obstructions before the end of the calendar year if the winter is mild and the temperature of the river water has not been much lowered, but those fish running up in November, December, January, and February, are not going to spawn till the next November.

It will be clear from this that if a salmon pass is designed to take up spring fish, it must have such an easy gradient that they can swim up. It is virtually impossible to use this form of pass at a perpendicular dam.

To deal with problem of the high dam, special forms of fishways have been invented in America so that the fish may be carried up. I have not had an opportunity of seeing any of these elevator, cable hoist, or tramway passes, for in America I have not been west of the Rockies, but the idea was introduced years ago by Americans like Kirk, Recken, Atkins, and Shaw, and an elevator pass was pat-

ented in Scotland by Malloch in 1890. Most of those early artificial arrangements were failures. Perhaps it would be more accurate to say that all of them were. I am not by any means certain that the larger and more modern developments are likely to be better, and I was surprised to see in the July number of *The Pacific Fisherman* that Mr. Henry O'Malley had been somewhat critical of one at a place called Concrete.

I have seen a great many salmon passes in this and other countries, in fact, there is no pass in Scotland that I have not seen in the last 25 years, but I repeat that I have never seen passes at immensely high perpendicular dams.

If the elevator type of pass is succesful in raising fish in limited numbers to the top of those dams, I still have to be persuaded about the resulting benefit to the river. It is not at all clear to me that the fry will get down, and there is little use breeding landlocked salmon.

It would be out of place here to enter upon a general discussion of salmon passes. I have done that on two occasions already, but I may say that successful passes have been erected at very few really high obstructions.

I might perhaps mention one which although not at a perpendicular dam, embodies an idea which might possibly be useful in the way of suggestion. A steep gully not far from the waterfall has been used for the pass, and a series of pools have been built up in this gully. The special point is that the walls cannot be overflowed by the descending water, which first strikes against an opposite wall and then has to regurgitate round an upstream projection of the wall, before it can find an exit from the pool. The effect is to give a strong check to the water flow. The drop to the next pool is between two and three feet, and the various drops are not uniform in order to allow of the pass being adjusted to the gully. The stream is a small one, and in order to get sufficiently attractive flow and counter any other flow, the whole stream is turned down the pass when fish are running the river. The total ascent is 70 feet.

At the Rukenfos in the Shire river in Norway, fish were able to ascend 89 feet in a long wooden pass of the Bracken type. The pass was not in pools, and fish had to swim all the way. The total length was 1050 feet, and a fourth of the length was in rock tunnel. Unfortunately the pass has been allowed to fall to pieces.

I regard the problem of the high dam as so difficult, that in considering the hydro-electric schemes in Scotland, I

feel it is necessary to treat the high dams as insurmountable by salmon. On this account I regard the impounding of water to be used expressly for fishery purposes as so important.

A good deal can be done to increase the facilities for the natural spawning of salmon, if compensation water is at command. If fish have difficulty in reaching the spawning gravels of a tributary, it may still be possible, by an increase of flow at the right time, to enable them to do so. If the physical conditions permit, it may even be possible to create small lakes at certain places, so that water may be stored. This has already been done in not a few cases in Scotland. Much however depends upon the nature of the surrounding country. If water is under control, it is also possible to use small streams where gravels are good for the planting of eggs transported from a distance. Experiments made by Mr. C. W. Harrison, a District Inspector in British Columbia, who invented a good carrying box, have shown that eggs planted in his way hatch out with a loss of from only 6 to 12%. A point to be noticed here is that even if the water in the stream is much reduced it will be sufficient for fry to descend.

The loss amongst descending fry of *Oncorhynchus* species is not yet very clearly known, but the valuable marking of yearlings by Dr. Rich and the late Dr. Charles Gilbert yielded a return of adult fish amounting to 1 1-5%. Earlier marking of wild smolts of *Salmo* in Scotland, yielded fully 2%, but grisle and small spring fish, which formed the bulk of the return catch, spend a shorter time in the sea than do the Sockeye and Quinnat. In both cases it is possible, of course, that some fish returned but escaped detection. The return is a small one, however, and this return cannot be improved by artificial hatching. It concerns the life of the young fish after it has descended the river.

The possibility of resorting to artificial hatching will occur to everyone, but in this connection there is the consideration of how best to secure the adult fish for stripping. Adult fish kept in confinement require a great deal of water, and, with the schemes we are now considering, this is the one thing they may have difficulty in getting. Confinement also rather impairs their health and is apt, in consequence, to produce eggs that do not make a very good hatch.

In considering the benefits of artificial hatching, there is one point which I should like to make.

It is very generally assumed that to hatch out a very large number of eggs and to turn out the fry, represents a clear gain to the stock in the river. It is argued that by artificial means, a much larger percentage of fry are secured than would be the case in nature. There is no doubt that it is easy to secure a very high percentage. But in estimating the benefit to one river, it is necessary to compare with accuracy the difference between the results of man and of nature. It is not sufficient to consider man's results alone.

If a proportion of adult fish are taken from a river in order to stock hatcheries, the artificial process consists in returning to the river the fry which those fish would themselves have produced, plus an unknown number of fry secured by the protection of the eggs in the hatcheries. This unknown number is the benefit to the river. It can only be roughly estimated, and it is not so large as hatchery enthusiasts generally make out. For the reproductive processes of Nature are never poor. On the contrary they are surprisingly efficient. We have already noted that salmon eggs can be planted in gravels with a loss of only 6% to 12%. Statements that great quantities of salmon eggs remain unfertilised do not seem to be borne out by the examination of the natural redds of *Salmo*. It appears to be the case that when, in the past, a superabundance of fish occupied gravels in rivers of the Pacific coast, large numbers of eggs were left unfertilized, but this does not occur under ordinary conditions. If it did, arguing by the analogy of what we find amongst sea fish with floating eggs, Nature would have required the salmon to produce a far larger number of eggs to make good the wastage. Again, if a river is declining by overfishing, the practice of artificially hatching large number of salmon eggs does not seem to be sufficient to build up the stock if the overfishing is allowed to continue. If the official figures for hatching in the State of Washington were examined, it will be seen that it is possible to hatch something like 180,000,000 eggs a year and have the fisheries still declining.

I am not argueing against artificial hatching as a method of increasing the stock of fish. One could select many cases in which distinct benefit can be shown. Quinnat salmon have become established in New Zealand on a scale sufficient to start commercial fishing, by the aid of artificial hatching alone. But I am asking that a common sense view be taken of this method of overcoming the difficulties of the hydro-electric schemes to which we have been refer-

ring. I am asking that too much should not be expected of artificial hatching in view of the adverse factors that are present. A farmer does not expect to raise stock in an arid desert, and salmon cannot be raised in dry water courses. After a time eggs cannot be got to fill hatcheries if adult spawners cannot get up the river.

The decline of salmon fishing is always a question of balance between catching power, and the number of fish left to keep up the stock, and if water power schemes bring about a serious reduction of spawning possibilities, whether natural or artificial, the catching power should properly be diminished. Men being what they are, one does not expect this, and one does not get it. So the inevitable result is, that decline rapidly developes and approaches the condition of extermination. Men will go on fishing till it no longer pays them to fish, and then the remnant of the salmon will begin, very slowly, to build up the species again.

Restriction of netting, before this calamity comes about, may check the period of decline. It is, of course, an unpopular interference with the liberty of the subject to get gain. All regulative treatment has something of this nature. But I do not see why the regulative treatment should be all on the side of the industry to be injured. I think the regulative treatment should first be for the people who are coming in to interfere with the water which is so essential to the fisheries.

It is reasonable, I think, to ask that they should be required to give an agreed-upon flow of compensation water, and that, if possible, they should store up water for the benefit of the fisheries as well as for their own benefit. Further, I feel strongly that when the difficulties which these large water power schemes raise are officially inquired into the settlement of regulative measures should not be left to be dealt with on the evidence of individual interests alone, since there is a large general interest as well as the separate interests of injured individuals.

Salmon passes at relatively low obstructions which suffer from diminished water flow, and all facilities for the spawning of fish should be encouraged, but it seems to me better that very high dams should be regarded as insurmountable than that adequate compensation in water be omitted from these schemes.

# THE GLAUCOUS-WINGED GULL IN ITS RELATION TO FISHING INTERESTS IN BRITISH COLUMBIA

By A. J. Munro

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During the past five years numerous complaints have been made by British Columbia fishermen concerning the destruction of food fishes by gulls and other fish-eating birds. Fishermen believe that this destruction seriously affects commercial fishing and ask that remedial measures be employed. Some go so far as to say that the consumption of fish by birds is greater than the toll taken by fishermen. On their part is a tendency to overlook economic and industrial developments, which are, perhaps, the factors chiefly responsible for the decreasing returns from commercial fishing.

As a general rule the harm which birds do is quite obvious whereas the benefits they confer upon man are not so apparent. In the case of birds versus fishes the relationship is so complex and involves so many other forms of life that years of study will be necessary in order to reach a clear understanding of the problem. It is believed that the question is of increasing importance and one that merits the attention of conservationists.

All species of gulls are protected under the Migratory Bird Treaty, a fact that has caused much adverse comment, for to the average fisherman "a gull is a gull" and all are emphatically condemned. To the naturalist, on the other hand, it is known that the various species have different feeding habits, distinct breeding ranges, and, in some cases, occupy different wintering grounds. Differences in their relationship with other water-fowl have also been recorded. For example it has been observed that California, Ring-billed, Herring, Glaucous and Western Gulls will feed upon the eggs and young of other birds to a greater or lesser degree, whereas the Glaucous-winged Gull appears to live at peace with its neighbors.

It is to the last named gull that the following remarks apply. This is the commonest species from Washington north to Alaska, and the only gull known to nest on the British Columbia coast. Over this area it probably outnumbers all other species of gulls and thus may be considered the most important from an economic standpoint. At any rate, when British Columbia fishermen are condemning gulls, in nine cases out of ten, it is to this species they refer.

Complaints of damage caused to fishing interests by "gulls" refer chiefly to:

a. The destruction of herring.
b. The destruction of herring spawn.
c. The destruction of salmon eggs on the spawning grounds.

DESTRUCTION OF HERRING BY GULLS. That an intimate relationship exists between water-fowl and herring is common knowledge. By the actions of gulls particularly the movements of herring are made plain to the observer and thus fishermen are indebted to these birds, in no slight degree, as a source of valuable information. The spawning of herring is immediately advertised by great bands of gulls gathering on the beaches which adjoin the spawning area; and by Cormorants, Murres, Mergansers, Scaups and other water-fowl invading the shallows where herring are congregated.

During the fishing season it is common to see loaded herring scows attended by large flocks of gulls. In these scows the fish are left exposed and full advantage is taken of the opportunity to secure an abundance of food with the minimum of effort. What the actual consumption amounts to would be difficult to determine but fishermen measure the loss in tons. Complaints of this nature are certainly justified but there is an obvious remedy. At a nominal expense herring scows could be decked in or equipped with canvas covers which effectually would prevent further loss. So far as I am aware no attempt to guard against loss in this way has been made.

The large number of herring consumed by individual birds under these artificial conditions has given rise to the belief that a habit of gorging is customary at all times but such is not the case. When gulls are dependent upon their own efforts to secure fish less eagerness is shown and the appetite is more quikly satisfied. It has been observed also that, except under very favorable circumstances, fish are captured only after considerable effort and that their fishing is not uniformly successful. Thus at Departure Bay last spring a band of twenty Glaucous-winged Gulls were observed following a school of adult herring for several hours and during this time only three birds succeeded in making a capture. It was noted also, in each case, that the successful bird, after swallowing the fish, rested on the water and took no further interest in the fishing. In examining the digestive tracts of Glaucous-winged Gulls, taken from specimens which had been shot as they rested on shore, it was found that many of the

birds so taken held a pellet of mascerated bones in the stomach—the remains of the penultimate meal—and one freshly taken fish in the gullet. As the birds rested after taking one fair-sized fish it can be assumed that, under normal conditions, this amount of food satisfies the appetite for the time being.

CONSUMPTION OF HERRING SPAWN BY GULLS. Last spring a preliminary investigation of the destruction of herring spawn by gulls was undertaken and the evidence obtained would indicate this destruction to be a matter of slight importance. With every tide herring spawn is stranded on the beaches; after a wind storm the spawn is often piled up at high water mark to a depth of several feet. It is upon these waste eggs, rapidly undergoing decomposition, that gulls feed.

DESTRUCTION OF SALMON SPAWN BY GULLS. During an investigation of this question on Vancouver Island the stomach contents of twenty-four Glaucous-winged Gulls were examined. It was found that salmon flesh comprise 75 per cent and salmon ova 25 per cent of the food taken. In this particular area an enormous wastage of spawn occurs, due chiefly to overcrowding on the spawning beds. These eggs drift down stream and lodge in the shallows where they are soon killed by exposure to light. It was upon these drifting eggs, whose loss is assured in any case, that gulls were feeding

Such are the feeding habits of the Glaucous-winged Gull which adversely may effect man's interest.

On the other side of the ledger certain habits and qualities must be credited the species as being beneficial to man. Their value as scavengers cannot be overestimated; the sea-beaches are kept clear of fish and carrion of all sorts, which, if allowed to remain, might become a menace to health. On the spawning grounds of salmon the work done in this respect is remarkably efficient. Almost as soon as a dead salmon drifts ashore it is found by the gulls (which gather solely for this purpose) and in a short time is picked clean to the vertebrae. At canning factories, or other places where fish are cleaned, gulls take care of all discarded offal. About our coast cities they aid sanitation by feeding on sewage which is dumped into the harbours.

Not so well known are the good offices performed by the gulls in destroying noxious insects. Along the southern coast of British Columbia when winter ploughing is in progress the Glaucous-winged Gulls gather on the fields to feed on the larvae of destructive insects that are turned up by the plough. Every foot of ground is combed over for these grubs; cut-

worms, wire-worms, and army worms are destroyed in thousands. Gulls become so tame they will follow a few feet behind the plow and alight on the freshly turned earth a few seconds after it falls aside from the plough share.

Last but not least is the aesthetic and educational value of the Glaucous-winged Gull. During the winter months it is the most conspicuous bird about our Coast cities flying overhead, walking on the streets and lawns, and perching on the buildings in the down-town sections. Children learn to watch for these birds in order to feed them and thus is awakened an early interest in wild-life which may well be the first step in the creation of a bird lover and conservationist. As an instance of their local popularity it might be mentioned that the City of Victoria has adopted the slogan "Follow the Birds to Victoria"—the birds in this case being the Gulls which attend the steamers on the triangle Run between Vancouver, Victoria or Seattle.

It may safely be said that gulls with their beauty, their friendliness and the wonder of their soaring flight have given more pleasure to travellers than any other bird in existence.

Of the relationship between gulls and fishing interests very little is known, and in the preceeding remarks I have tried to indicate how complex is the question. The fishermen, observing that gulls eat fish, conclude that an increased supply of food fishes can be secured by destroying the gulls. This simple theory is not acceptable to the biologist who knows that food fishes form only one of the many items of the diet of gulls and suspects that their destruction of other forms of life, perhaps inimical to fish propagation, may strike a balance in their favour. It is notable that in the few studies which have been made of birds versus fishes, in every instance, the birds complained of were found to be either neutral or beneficial in their relations to fishing interests.

The general question of birds in their relations to food fishes has not received the attention warranted by its economic importance and exact knowledge of the subject would appear to be essential to intelligent conservation. Particularly so at this time when fishermen and anglers are asking that many species of birds be removed from the protected list. Fishermen regard fish-eating birds as their greatest competitors but their indictment of such species as Mergansers, Gulls, Grebe and Loons is supported by circumstantial evidence only, which should not be accepted by the scientific conservationist.

I submit that this branch of economic ornithology has been neglected and would urge the necessity for local studies of the food habits of all fish-eating birds.

# FISH CULTURE IN LOUISIANA

*Director of Fisheries, Department of Conservation of Louisiana*

BY PERCY VIOSCA, JR.

Persons who do not know me personally will be interested to learn I do not belong to the group of practical fish culturists but rather to the class of so-called theoretical scientists. I have had an acquaintance with fish life in connection with my work in general ecology, but I have never read a book on fish culture in my life. It fell to my lot to take over the fisheries of Louisiana about eighteen months ago. Upon assuming those duties I found that the fish culture in Louisiana, having gone through various stages of evolution, had reached a fairly high state of development. I had to correlate my knowledge of ecology with the little I could gain of the existing state of fish culture and conceived the following plan. I do not know whether it contained a single new idea or not, but I am presenting it to you in case it may contain something new.

The experiments here described were really only a beginning. We selected the animals and plants which we found growing most abundantly in places where the large-mouthed black bass produces a maximum output in natural waters. We carried out two of those experiments during the past winter in twelve acre ponds, the depth of which varied to a maximum of six feet. We found that the black bass were abundant in proportion to the length of the shoreline and in order to get a maximum amount of shoreline in these ponds we simply ploughed large sections with road machinery and made a series of hills which projected above the water line. The idea was to further the cultivation of shoreline creatures which would act as food for the black basses and other species of fish which we were cultivating.

In addition we possibly have a new idea in regard to the hatchery part of this collecting pond. The hatchery itself was a one acre section of the twelve acre pond, entirely enclosed by chicken wire In it we placed one hundred pairs of black bass and an assortment of the sun fishes which are found in that locality. In the hatchery part there was a maximum amount of shoreline in proportion to water area, and at the same time deep water for the large bass. On leaving the nests the young migrated and practically all of them went out into other sections of the pond which had been prepared for them.

We selected plants which grow vertically in preference to those, such as water lily, which have a leaf blade on the surface, because the vertical plants produce the acid conditions desirable in our warm waters. At the same time plants, like Sagittaria and some of the Potomogetons, produce the necessary oxygen requirements and also serve as food for the small crustacea and the smaller fishes.

As to animal life, we had the small water fleas, such as Cerodaphnia; then crawfish, the Hyalella, Gambusia, some of the shiners, and the gizzard shad—all of which were planted in the open area of the pond. I had occasion just before I left New Orleans to observe the results of this experiment and I found that everything seemed to be propagating in tremendous abundance. The hickory shad, the shiners, the Gambusia minnows, were seen in numbers. There was an abundance of the bar fish. I do not know whether this species has ever been raised in captivity before. In one of our ponds which is fed by a spring-fed stream, the water being taken out of the lake with a pump, we have bred for the first time a new species of black bass, the Kentucky bass, which is very abundant in all our southern states.

One ton of horse manure per acre was applied to the ponds before the water was let in. We have not fed a single fish. Of course in trout propagation where there is relatively sterile water all feeding has to be done artificially. Our idea was to cultivate the food upon which the basses feed and let the bass take their own live food when and where they saw fit. The young bass as they left the eggs began feeding on the Cerodaphnia and then began to take the larger food forms. We are not trying to raise a certain number of fish per acre. We have never considered and we do not know how many fish per acre we are going to raise; the dominant thought is, how many pounds per acre of black bass and other fish we can produce. When I saw the black bass. before leaving New Orleans, they were three and a half months old and measured about seven inches in length.

## GRAYLING IN THE EAST

By James A. Laird

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It has been proved that grayling eggs can be shipped from Montana in the usual way, incubated, and the resulting fry reared to adult size with practically the same equipment used for trout. Whereas trout rearing in suitable water is not a difficult procedure, the rearing of grayling because of their short incubation period, their minuteness when hatched, their natural desire for plankton and natural food and the extreme difficulty in making them take artificial food, presents difficulties hard to overcome.

The trays for hatching should be of smaller mesh than the regular trout trays, one quarter inch by one sixteenth inch mesh is none to small to prevent the eggs which run about seven hundred to the ounce from dropping through the larger mesh. The top and bottom trough screens must be of copper wire cloth about twenty to twenty-four squares to the inch for the fry when hatched are so small that any coarser mesh allows them to escape or to force their heads through the mesh with consequent loss. The water supply must be small since they are weak swimmers and can stand little current the first few weeks. The water should be from a pond or creek that has a plentiful supply of plankton or minute organisms.

Grayling eggs hatch in fifteen days at fifty degrees, swim up in twenty-four to forty-eight hours after hatching and must be fed before swimming up, then fed every half hour from daylight to dark, for they are voracious eaters once they start feeding.

Beef liver seems to be the best food at first. It is ground and reground six or eight times through a one-sixteenth inch plate and then sifted through a kitchen strainer of the finest mesh so that only the finest particles get into the trough. What is left in strainer is fed to trout fingerling or larger fish. No water is added to the liver. A lump is put in the strainer and agitated at the head of the trough and also at a place a little below the first third of the length, because the fish are prone to bunch at the foot of the screen. Covering the lower third of the trough seems to prevent bunching up for they seek the light.

When the fry have grown to three quarters of an inch in length they may be put out in rearing ponds and easily fed beef hearts or lamb hearts and some lamb liver. They will

eat lungs also but the mouths are very small and the food must be finely ground.

Dr. I. H. Treece, Field Superintendent of the Montana Fish Commission recommends the planting of eyed eggs and also fry just after hatching. I will quote from his letter to me, as follows:

"Mr Thompson has passed your letter regarding the shipment of Grayling on to me and wished me to try and enlighten you on the Grayling question, if I can. . . . . .

. . . . . ."In the first place your Grayling are too young to tell much about what they will do yet in the way of spawning. Grayling grow very fast in Georgetown Lake and do sometimes run when two years old but we seldom ever take the eggs of the young fish as we have numerous older ones.

You will find the grayling proposition one of the toughest you have ever undertaken. I have studied it for ten years and know very little as yet about it. I do know for sure that if they come in your pens green, you might just as well turn them lose for they will not mature in an inclosure. I have held graylings under all manner of conditions and the eggs will just not ripen until the fish are liberated.

Grayling are not particular about where they spawn, that is they will spawn on a gravel bed or out in the weeds along the shore where there is no gravel. They pair off to spawn and I never saw any other fish spawn just as they do; the male and the female will get just as close together as you could place your two fingers and then both spawn at the same time, I do not believe that they make any effort to cover the egg with gravel as do trout; in fact I believe the most of the eggs hatch without any cover.

In planting grayling eggs we do not cover them as we do the trout eggs for I am not sure if the little fellow can wiggle out of the gravel. We get wonderful results from planting the eyed egg, but they are placed where they are not in much danger of being disturbed and will hatch very quickly.

I wish you would take some of these fry and plant them in your waters just as soon as they are hatched to see if the proper feed is in the water for the little fellows. If the food is not there the grayling will never successfully stock your waters."

Once started, grayling are more easily reared than trout, at least I have found it so in our waters and there is little loss from disease. They will not stand as much handling as a trout, and a very short time of suspended aeration is fatal. There has been a tank containing a hundred two-year-old gray-

ling in the New York Aquarium for a year and they still seem to be in excellent condition.

Grayling are late spring spawners and should make good fishing in the closed season for trout and possibly could be used in brooks no longer fit for trout due to higher temperatures. Grayling are non-cannabalistic and would improve any lake in which there is plenty of minute food. I would like to see some new artificial lake stocked alone with grayling as an experiment.

Our plan at the South Side Club is to stock one of our ponds for fall fishing after the trout season closes and not mix grayling with trout, for we find the grayling too easily taken with dry or wet fly and not as good a game fish as the eastern brook trout.

I take this opportunity to publicly thank the United States Bureau of Fisheries through Mr. W. T. Thompson, Superintendent at Bozeman, Montana and Dr. I. H. Treece, Field Superintendent of the Montana Fish Commission of Anaconda, Montana for their help and cooperation in the experiment with Montana grayling, also Mr. T. F. Wilcox and Mr. C. B. Spears, Fish Committee members of the South Side Sportsmens' Club who sponsored the experiment.

I believe there are great possibilities with grayling, a beautiful and fine fish now extinct in Michigan.

# MORE ABOUT FISH FOOD

By M. C. James

*U. S. Bureau of Fisheries*

If we consider the amount of time which has been given to discussions of the fish food problem in previous meetings of the American Fisheries Society, it must be conceded that this question looms large in the minds of the members. It is very probable, however, that the fish food problem is viewed by each fish culturist in the light of his own particular conditions, as is frequently the case, and little consideration has been given to the problem as a whole in the way of defining it.

It therefore seemed desirable to have some idea of what is involved in the feeding of the hundreds of millions of hatchery fish reared in this country. Questions as to the total tonnage, total cost, and the different varieties of diets employed seemed worth answering. Accordingly the bureau set out to gain an idea of what these facts may be by the familiar questionnaire method. Many of you received these questionnaires and will recall their nature, but for the benefit of those who may have been inadvertently overlooked, or whose names did not appear in the bureau's files, it may be said that they requested information on the total poundage of feed, the total cost, the number of pounds of the common liver and heart foods utilized, with a space for a statement concerning the kinds and quantities of other foods utilized. Request was also made for an expression of opinion as to the most satisfactory food.

Such an undertaking, of course, lacks the value of the original research which is being so vigorously pushed in various fields, and furthermore it is admittedly incomplete in that some fish-cultural agencies were not reached, and no replies were received from others. It is not statistically absolute and represents only minimum figures for the various items. At the same time I feel that the compilation may furnish you with food for a few moments thoughts. In passing I may add that Mr. Titcomb has had an opportunity to view the replies, and has furthermore been of assistance in corraling some recalcitrant replies. Possibly his interpretations and conclusions may differ somewhat from mine.

To be brief, we received 77 replies. Since the States were sent only one questionnaire to cover all of their hatcheries, the replies received really represented a total of

216 hatcheries. Added to these were 44 federal hatcheries and feeding stations, making a total of 260 hatcheries under review. In comparing this with the actual number of hatcheries in operation, I would state that an estimate prepared in 1927 gave us a total of 296 State, Government, and private hatcheries in actual operation. Doubtless by now the number will be well above 300. The replies, therefore, cover a fair portion of the field.

At the outset, one of the first impressions gained was that in some cases there was considerable uncertainty concerning the quantity of food used. There appeared to be either a lack of definite records, or else a hesitancy in divulging them. It was noticeable that in most cases the question of cost was more closely determined. Also in some of the replies there was a vagueness or ambiguity which left them open to various interpretations and may account for any divergencies in the conclusions reached by Mr. Titcomb and myself.

The totals showed that at least 6,879,439 pounds of miscellaneous materials were fed to hatchery fish during the year. In other words our fish have gotten away with 3,439 tons or two good sized trainloads. The figures indicate that this amount of material cost a total of $270,797.15. To some of you who are paying 22 cents a pound and upward for beef liver there may seem to be a discrepancy in these cost estimates, but it should be pointed out that the average cost was reduced to approximately 3.9 cents per pound by the feeding of hundreds of thousands of pounds of horsemeat, fish, middlings, etc. at virtually the cost of handling. Furthermore the figures covered the period previous to July 1927, before liver was hailed by the doctors as a potent curative agent.

The reports showed that 35 different articles appeared on the piscatorial menu. Since many of these comprised different kinds of liver, or different species of fish, they could be condensed into 19 general classifications. To give an idea of what the other fellow is feeding, I will enumerate the diets: Sheep plucks, liver, beef heart, spleen, lungs and sheep liver; pig liver, milts, plucks, hearts and lights, horse and cow meat, fish meal, salt and fresh salmon, and condemned canned salmon, herring and several other species of fresh fish, middlings, red dog flour, and several other materials of like nature, beans, including Mexican pinto and soy beans, commercial fish foods of which Fishotein is an example, and Lactein and cod liver oil. Likewise a

little blood, a few boiled eggs and potatoes, considerable milk, including buttermilk, shrimps and shrimp heads, fish waste and a few other assorted tidbits in small quantities.

Now having reached the point where we can compare the relative quantities of the various foods used, we can expect to have a straw vote on the most popular and consequently the most satisfactory fish food. The relative order of consumption was as follows: First, sheep plucks with a consumption of over 1½ million pounds. Following this in the order named were (2) horse and other fresh meats, (3) beef liver, (4) pig liver, (5) beef lungs, (6) fish products, (7) cereal products. There exists a question relative to the interpretation of the reply of one of the States which may affect the standing of sheep liver, and likewise there was some uncertainty as to the actual quantity of beef lungs utilized, but it appears that the list as given above is approximately correct. The other materials mentioned previously were in such limited quantities that it appears they are of importance only locally. For example, the feeding of cornmeal, oatmeal, dried buttermilk and hard-boiled eggs is reported in a few instances. The figures speak for themselves, and we have to assume that the fish culturists are making their choice of one food against the other on the basis of the relative values in the production of more fish and bigger fish at the lowest possible cost. Whether the choice would be the same if certain conditions were altered, is a question and more of that later.

Analysis of the complete returns reveals another situation which should be fruitful of consideration. The commercial and private hatcheries replying, numbered 50, or about 19 per cent of the total. They used about 6.9 per cent of the costly beef liver and about 20 per cent of all the beef heart fed. But the same 19 per cent accounted for a consumption of 72 per cent of the horse meat which is notably inexpensive. The same 19 per cent was also utilized 46.5 per cent of the poundage of sheep plucks which are of moderate cost. When we come to the really low cost foods, we see them using 71 per cent of the total poundage of cereal products, and 49 per cent of the fresh and salted fish products. The same 19 per cent, however, spent $107,404.22, or about 39 per cent of the total expanded for fish food. As for the expenditures of the individual agencies, I will merely reveal that for the year ending June 30, 1927, the Bureau of Fisheries fish food bill was about $25,000 or

approximately 6 per cent of the budget covering miscellaneous and distribution expenses. Since the percentage of fingerlings or fed fish distributed for that same period was only about 3 per cent of the output, the figures are somewhat out of line. The expenditure of the bureau for fish food exceeded that of any single agency questioned, with the exception of one of the States, and that reply was so stated as to cause some uncertainty as to the exact sum.

It has been something of a strain to stick to bare facts and figures without indulging in a little speculation concerning what it all means. To me one of the most interesting points is the showing that the commercial culturists are apparently largely influenced in their choice of fish food by the factor of price alone. The fact that they are continuing in business and presumably making money, and that new commercial establishments are being constantly started, indicates that these low priced foods must have a real value. That naturally leads to the question as to whether the states and the federal government may not be wasting their money on feeding so much more of the expensive beef liver, heart, etc. I believe this accusation will be refuted by a consideration of the different aims and objects of the two classes of hatcheries.

The long feeding period involved in the production of mature fish and eggs by the private growers does not figure so strongly in the raising of large numbers of fry and small fingerlings for public distribution. Practical results and a multitude of experiments seem to justify the attitude apparently held by the state and federal hatcheries and at the same time the verdict of the pocketbook seems to support the views of the commercial men under their own special conditions. As the sentiment for the distribution of larger fish to public waters becomes stronger, I believe we all will veer more and more toward the feeding practices of the private hatcherymen. It is noticeable that hatcheries which are distributing fry and fingerlings give little thought to the food problem, but as they adopt a program of rearing fish there is usually a rush for all possible information on the problem and a flurry of experimentation.

I have concluded that any new fish food resulting from such experiments must, if it is to receive a wide acceptance, possess in addition to proper dietary values, comparable to those of fresh meats, a dependable source of supply for

large quantities, and it must be available at a price not to exceed 5 or 6 cents per pound. These two latter factors are frequently overlooked in searching for new foods, but it appears to me that they must be given fuller consideration in any attempt to displace food materials now in common use.

Finally that 270 odd thousand dollars of the annual feed bill represents a fixed charge on the fish-cultural operations in this country. Efficiency experts advise us that economical and effective administration of any activity must be based upon a reduction of all fixed charges to an absolute minimum. We have therefore been instinctively groping in the right direction in our search for cheaper and better fish foods. At the same time, however, I am afraid that the particularly "fixed" charge is liable to become "unfixed" and revised in an upward direction if the sportsmen continue to demand that we plant fish big enough for the frying pan, and the doctors discover more therapeutic values in what an earlier generation considered cat-meat.

# A LIST OF THE PLANT AND ANIMAL FOOD OF SOME FISHES OF JAY COOKE PARK.

By Patience Kidd Nurnberger

*University of Minnesota*

During the summer of 1925, Eugene W. Surber made a biological study of the waters of Jay Cooke Park, Carlton County, Minnesota, including streams within and adjacent to the park and a section of the St. Louis River. The object of the study was to determine the natural fitness of the waters for the production of fish. The general conditions were observed and chemical tests were made. In addition, a number of small fish were caught by seining and these were preserved for future study.

The present paper deals with the results of an investigation of the digestive tracts of the small fishes. No attempt was made to obtain representatives of each species found in the park, and, therefore this list will be necessarily incomplete as far as the entire water system is concerned.

Since the fish were taken from purely natural habitat, the results indicate very well their preference when given full freedom of choice. The fishes range in size from 10 mm. to 45 mm. in length.

The food of the fishes was as follows:

*Catostomus commersonnii* (Lacepede), Common Sucker: algae, rotifers, entomostraca, insects and their larvae.

*Notropis cayuga* (Meek), Black-sided minnow: algae, sponges, insects and their larvae.

*Notropis cornutus* (Mitchill), Shiner: algae, rotifers, entomostraca, insects and their larvae.

*Salvelinus fontinalis* (Mitchill), Brook trout: insects.

*Umbra limi* (Kirtland), Mud Minnow: Algae and insects.

*Eucalia inconstans* (Kirtland), Five-spined Stickleback: algae, sponges, entomostraca, insects and their larvae.

*Boleosoma ictalops* (Rafinesque), Johnnie Darter: algae, entomostraca, insects and their larvae.

*Cottus ictalops* (Rafinesque), Miller's Thumb: algae, entomostraca, insects and their larvae.

Algae were recognized in the food of all but one of the fishes examined. In one species only, the Sucker, the algae are the most important food. For this fish, algae constitute 75 per cent to 95 per cent of the entire food. The other species of fish use animal food. However, in all cases, this animal

food consists of forms which are primarily algal feeders. Whether or not the fish eats the algae directly or consumes animals which eat algae, the algae are always the first link in the food chain as indicated below.

ALGAE { Rotifers, Chironomus larvae, Entomostraca, Insects } FISHES

As more and more attention is being given to the food of fish in the United States and as attempts are being made to imitate natural conditions in the artificial raising of fishes, it is interesting to note what is being done in this connection in foreign countries. For instance, in the Philippine Islands, since before historical records, the natives have maintained large numbers of artificial tanks in the vicinity of Manila Bay, where they raise their most important food fish upon algae alone. As information is gathered together one realizes more and more the importance of algae in the food chain of fishes.

As the work progresses, one finds the necessity of being more familiar with conditions of nature, the associations and the dependence of animals upon plants or other animal food.

Since it is known what an important part algae play in the life of fishes, one must come to the conclusion that a taxonomic as well as an ecological study of the algal food is a necessity.

The following is a complete list of the algae indentified—as far as genera—from the digestive tracts of the fishes of Jay Cooke Park.

Blue green algae (Myxophyceae).

| | |
|---|---|
| Aphanothece | Merismopedia |
| Microcystis | Oscillatoria |
| Coelosphaerium | |

Diatoms (Bacillariales)

| | |
|---|---|
| Cymbella | Synedra |
| Amphora | Fragilaria |
| Gomphonema | Licomphora |
| Cocconeis | Tabellaria |
| Nitzschia | Melosira |
| Diatoma | Surirella |

Green alage (Chlorophyceae)

| | |
|---|---|
| Sphaerocystis | Docidium |
| Scenedesmus | Micrasterias |
| Selenastrum | Ulothrix |
| Pediastrum | Stichococcus |
| Closterium | Cladophora |
| Staurastrum | Stigeoclonium |
| Cosmarium | Spirogyra |
| Gymnozyga | Oedogonium |

# THE FOOD OF THE RAINBOW TROUT IN MICHIGAN

By Dr. Jan Metzelaar

*Fisheries expert, Michigan Department Conservation*

During the summer of 1927 a survey has been made of food of certain important fishes, first of all the Rainbow Trout.

About 1,000 half pint glass jars filled with formaldehyde and with a blank tag attached to every jar were distributed to various individuals and clubs; also to Chapters of the Izaak Walton League. The tag asked for a record of the name and address of the fisherman who caught the fish; the length of the specimen, the stream, locality and state where it was caught.

Of 1,000 jars 350 were returned to me; of these 205 were filled, the balance being returned empty. A considerable number of them contained stomachs of brown trout which were saved for future study. Of rainbow trout stomachs there were 451: they were emptied and the contents soaked in weak formaldehyde; in those cases where more than one trout was recorded from a single locality the stomach contents were lumped together and studied jointly. In this way I obtained about 200 individual lots. Almost invariably the the individual trout in one lot were very nearly of the same size.

These lots were sorted out as to their various constituents and the volume of each in every lot was measured in cubic centimeters with a degree of accurateness of 0.1 cc. A detailed account of the entire analysis including all the data as supplied by the fishermen is on file in our office. From this specified account an abstract will be given here, arranged by river systems.

The term "land insects" includes all insects which do not live in or on the surface of the water when adult. It also includes spiders.

"Aquatic insects" includes both aquatic insect larvae and adults which normally live in or on the water, like "water-striders."

"Fish" includes a variety of minnows and a few game fishes of which a detailed special account will be given.

"Crustacea" primarily means crayfish but includes a small percentage of shrimp or "scuds."

"Worms" means exclusively the common earthworms.

"Vegetation" is almost entirely composed of filamentous green algae. The fact that a very considerable quantity of

these algae is consumed by the trout, especially by the larger ones is considered one of the main contributions of this report.

"Trash" means: gravel, sand, sticks and other indigestable stuff. Part of this was undoubtedly derived from the houses of caddis-worms which disintegrated in the stomachs. In one instance I found tin-foil, in another a mass of printed paper.

"Unidentified" is a digestible, but disintegrated mass of residue. In order to reduce the percentage of this item as much as possible I at first assumed that in the numerous cases in which a single item constituted the bulk of the contents, the unidentifiable remainder was of the same nature as the bulk and therefore was lumped with it so that it does not figure in the column for the "unidentified".

After every analysis the various constituents were saved kind by kind and at the end of the work the totals, obtained in this way, were remeasured and screened with a tea sieve. From the land insects, aquatic insects and vegetation, a fine dust was obtained in this way, but not from the other constituents. In case of both land and aquatic insects this dust is composed of minute particles of these two groups of insects; furthermore fragmented shells and sand. In the case of vegetation this foreign matter was composed of sand only. Inasmuch as it was impossible to sort out these fine particles volumetrically it has been assumed that the different constituents were present in the "dust" in the same proportions as they figure in the average proportions, calculated from the grand totals. In this way correction co-efficients were obtained for the five constituents mentioned. This correction co-efficient is small and of little consequence for the groups "land insects", "aquatic insects" and "vegetation" but considerable in the cases of snails and trash both of which are always represented in much smaller percentages.

Summary of Rainbow trout stomach contents by River Systems in **percentages** based on corrected totals.

| River System (in Michigan) | Number of trout | Land insects | Aquatic insects | Fish | Crustacea | Worms | Snails | Vegetation | Trash | Undefined | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Sault Rapids, Chippewa County | 2 | 7.1 | 0.9 | 33.2 | 57.1 | ..... | ..... | ..... | 2.1 | ..... | 100.4 |
| Sturgeon River, Cheboygan, Otsego Co. | 16 | 10.1 | 0.8 | 0.8 | 34.1 | 12.8 | 12.8 | 0.8 | 40.5 | ..... | 99.7 |
| Pigeon River, Otsego County | 14 | 0.2 | 13.4 | 42.5 | 7.9 | ..... | 20. | 9.6 | ..... | 6.4 | 100.0 |
| AuSable River, Main Stream | 127 | 9.7 | 57. | 2.5 | 10.9 | ..... | 0.3 | 12.0 | 4.9 | 2.7 | 100.0 |
| AuSable River, North Branch | 14 | 1.9 | 28.1 | 6.3 | 16. | ..... | 0.6 | 37.5 | 9.1 | ..... | 99.5 |
| AuSable River, South Branch | 27 | 33.1 | 12. | 0.6 | 1.8 | ..... | 10.2 | 11.1 | 22.5 | 8. | 99.3 |
| Pine River, Alcona County | 28 | 24.8 | 57.5 | ..... | ..... | ..... | 11.2 | 0.3 | ..... | 6.2 | 100.0 |
| Rifle River, Ogemaw County | 13 | 30.6 | 17.6 | ..... | 23.4 | ..... | ..... | 7.2 | 0.5 | 20.7 | 100.0 |
| AuGres River, Iosco County | 5 | 78. | 7.3 | ..... | ..... | ..... | ..... | ..... | ..... | 14.6 | 99.9 |
| Cedar River, Gladwin County | 16 | 57.8 | 0.9 | 19.4 | 21.9 | ..... | ..... | ..... | ..... | ..... | 100.0 |
| Pine River, Lake and Osceola Counties .. | 18 | 27.2 | 55.1 | 5.6 | ..... | .... | 1.9 | 7.8 | 1.2 | 0.9 | 99.7 |
| Manistee River | 37 | 7. | 33.5 | 7.1 | 21.6 | 2.0 | 0.1 | 24.9 | 3.4 | 0.2 | 99.8 |
| Little Manistee River | 12 | 0.2 | 4.8 | 28.9 | 56.7 | 4.0 | ..... | 0.4 | 5.2 | 0.1 | 100.3 |
| Sauble River, Mason County | 12 | 12.7 | 0.3 | 2.9 | 30.6 | ..... | ..... | 52. | 1.7 | ..... | 100.2 |
| Pere Marquette River | 77 | 32.2 | 32.4 | 5.2 | 19. | 0.2 | 0.5 | 6.9 | 3.3 | ..... | 99.7 |
| Strays, No locality | 19 | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... | ..... |
| Muskegon River | 15 | 8.5 | 56.5 | 0.6 | 34.4 | ..... | ..... | ..... | ..... | ..... | 100.0 |
| Totals, remeasured and corrected, figured out to average percentages | 451 | 12.8 | 28.3 | 10.9 | 23.9 | 1.3 | 3.6 | 12.1 | 4.2 | 2.5 | 99.6 |

Great interest is attached in sportmen's circles to the percentage of fish food eaten by the rainbow trout; therefore I have made this item the subject of some further study. The lengths of the trout from which the stomachs were saved ranged from 7 to 28 inches. These were grouped in 21 classes (from 7 to 8 inches, 8 to 9 inches, etc.) and the frequency with which every class occurred was plotted for all the trout and compared with the frequency of occurrence of fish in the stomachs of trout of the different lengths. From this plotting it is very evident that the frequency of occurrence of fish is very much the same in the 7 to 16 inch classes and runs around 6 per cent; there is a sudden break at 17 inches and from this length up the frequency of fish is rather uniformly around 33 per cent.

For this reason I have divided the trout in two groups, one from 7 to 16 inches and another from 17 to 28 inches and figured out the various food items for both groups.

| | Corrected per cent eaten by rainbows of 7 to 16 inches | Corrected per cent eaten by rainbows of 17 to 28 inches |
|---|---|---|
| Land insects | 18.6 | 2.9 |
| Aquatic insects | 44.6 | 1.7 |
| Fish | 3.5 | 23.9 |
| Crayfish | 12.6 | 43.3 |
| Worms | 0.3 | 3.4 |
| Snails | 5.0 | 0.1 |
| Vegetation | 9.0 | 17.9 |
| Trash | 3.0 | 6.4 |
| Undefined | 3.4 | 0.4 |
| | 100.0 | 100.0 |

Incidentally it was found, that the average run of fish from the less popular streams, like Muskegon, Bigelow Creek (Newaygo County), Little Manistee and Sauble River is considerably larger than from famous and intensely fished streams like the AuSable and Pere Marquette Rivers.

In 451 stomachs fish remains were found in 33 cases. Out of these there was *trout or trout eggs in 7 cases and young bass in ¼ cases.*

The following species of fish were identified among the fish remains in the 33 rainbow trout stomachs by Dr. Carl L. Hubbs of the Museum of Zoology, Ann Arbor Mich: Trout (6.3%); trout eggs (9.5%); muddlers (50.6%); minnows (7.4%); l.m. bass (2.1%); darters (4.2%); suckers (13.3%); undeterminable (6.6%). Percentages refer to total fish remains.

CONCLUSION: It is very instructive to compare the food of adult trout as given in this report with that of young trout of less than 7 inches. Of the trout taken in the AuSable River in 1924 I studied the food of 460 young specimens. Of these 224 were rainbows, the balance being brook and brown trout. None of the rainbows was over 5¾ inches long. I found in the stomachs of 60 seperate lots, totalling 224 young rainbows:

| | |
|---|---|
| algae | 1 case |
| land insects | 21 cases |
| aquatic insects | 35 cases |
| worms | 1 case |
| sand | 1 case |
| shells | 1 case |

This means that these young rainbows subsist almost exclusively on different kinds of insects. Exactly the same applies to the other two kinds of trout. Consequently there is not much difference in the food of the young of the three species of trout and they all compete one with another.

However, the older rainbows from 7 to 16 inches feed to a lesser extent on insects, land and water insects aggregating 63 per cent. This means that they are still competing with brook trout (although to a lesser degree), according to our general knowledge of the food of the brook trout.

The real large rainbows from 17 inches and up are apparently entirely turning away from insect food (aggregating less than 5 er cent). They very largely take to fish, crayfish and vegetation (algae), these three items totalling 85 per cent of the food eaten. In other words rainbows of this size cannot be considered serious competitors of brook trout in food matters. In order to get more accurate data on this subject we have this year distributed 1500 jars among the fishermen to save stomachs of brook and brown trout. The results of the analysis of these stomachs will be published in the next issue.

The present investigation does not yield any evidence that brook trout is actually destroyed by big rainbows from May first to September first. Out of 451 cases there was fish in 33 stomachs aggregating 83 cubic centimeters. Of this amount 6.4 cc. is probably trout (2 specimens). This ratio of trout eaten by trout is perhaps exceeded by adult brook trout, exact figures being not yet available.

It has furthermore been found that rainbow trout eat their own eggs to an appreciable degree; the latest date on which eggs were found was May 14, which means that May 1 is an inadequate opening day for the trout fishing season.

# THE FOOD OF TROUT FROM THE STREAMS OF ONEIDA COUNTY, NEW YORK STATE*

By Wilbert A. Clemens, M. A., Ph. D.

*Pacific Biological Station, Nanaimo, B. C.*

From April to September inclusive, 1916, a biological survey of the streams of Oneida County, New York State, was carried out for the State of New York Conservation Commission for the purpose of determining their suitability or non-suitability for various species of trout. A general report, was issued, (Clemens 1927). In the course of the survey, collections of trout and acquatic organisms were made from practically all the streams and the present paper gives the results of the examination of the contents of the alimentary tracts of the trout collected. Because of the amount of work involved in the detailed study of the food taken by the trout and the pressure of other duties, it has been impossible to bring the study to a completion until the present time but even at this late date it seems that the results are worthy of record.

The writer wishes to express his sincere thanks to Mr. James S. Gutsell for assistance in the field and to Mr. N. K. Bigelow for assistance in the study of the contents of the alimentary tracts of the trout.

Three species of trout were taken in 1916 in Oneida County, namely, *Salvelinus fontinalis*, speckled trout, *Salmo fario*, brown trout and *Salmo irideus*, rainbow. Considering the importance of trout from the point of view of angling and the extent of fish cultural operations associated therewith, the paucity of detailed information concerning the food of the various species is noteworthy.

Needham (1903) examined the stomachs contents of twenty-five speckled trout from Bone Pond, N. Y. and found the food to consist almost entirely of midge larvae, with the addition principally of *Corethra* and caddis larvae. Juday (1907) found that the principal food of 155 specimens of speckled trout taken in Twin Lakes and tributary streams, Colorado, consisted of insects but in two cases of young suckers. He also examined 106 specimens of rainbow trout and found that the food of these was comprised of chiefly insects and fish. Forty-two individuals had eaten fish some of which at least were young suckers. Smallwood (1918) examined 20 stomachs of speckled trout from Lake Clear,

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N. Y. and found the food consisted of grasshoppers, insect larvae, a minnow (*Leuciscus carletoni*), a pumpkin seed (*Eupomotis gibbosus*), a crayfish, and a snail. Pearse (1918) found that 18 specimens of speckled trout and one specimen of rainbow trout had fed largely upon insects and *Crustacea*. Embody and Gordon (1924) report insects, *Crustacea* and fish as the chief constituents in the food of 16 specimens of speckled trout taken in the vicinity of Ithaca, N. Y. Clemens and others (1924) found that the food of 25 specimens of speckled trout taken in streams tributary to Lake Nipigon, Ontario, consisted of fish and insects. Greely (1927) reported the examination of ten individuals of brown, five of rainbow and six of speckled trout from the Genesee River system, New York, and showed that insects constituted over 80 per cent of the food of each of these species. Fish were eaten by 3 brown trout and by 1 rainbow. Hildebrand and Towers (1927) found that the food of 142 speckled trout taken in Fish Lake, Utah, consisted chiefly of *Daphnia*, insects and *Gammarus*. Fish and fish eggs were eaten to a slight extent. Kendall and Dence (1927) studied the food of 167 speckled trout from the Alleghany State Park and found that aquatic insects constituted the bulk of the food with small fish taken in two instances.

There occur a few incidental references to the natural food of the three species mentioned above but it would appear that our present knowledge in this regard is largely comprised of the information contained in the above nine publications.

The speckled trout was doubtless originally abundant in all the waters of the County and although in 1916 it had disappeared or nearly so from some streams, it still was the most common and generally distributed trout. The brown trout had become well established in various streams especially in the Mohawk River . Specimens were taken in Beaver Creek (Holland Patent), Sconondoa Creek (Clinton), Kimball's Trout Brook, (Oriskany Falls), various streams in the vicinity of Rome, Cady's Brook (Remsen) Potash Creek (Lee Center). The introduction of rainbow trout did not appear in 1916 to have been altogether successful although specimens were being caught in a few streams. The individuals herein reported upon were captured in Deans Gulf (Clinton), Point Rock Creek, Tannery and Haynes Brooks and West Branch Creek (North Western), East Branch of Fish Creek (Point Rock).

In this investigation the contents of the whole alimentary tract were studied and the following numbers of individuals were examined; speckled trout 242, brown trout 16, rainbow

trout 15. Counts were made of the various organisms identified in each alimentary tract. Representative specimens of the various food organisms were weighed and these data were then used for the calculation of the volume percentages.

SPECKLED TROUT. The individuals of this species were grouped according to lengths as follows: 0-2 inches, 78 individuals; 2-4 inches, 77 individuals; 4-6 inches, 64 individuals; 6-8 inches, 13 individuals; 8-10 inches, 10 individuals.

Table 1. Food of 78 individuals, speckled trout, 0-2 inches in length.

| Food Organisms | *Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Spring Tails (*Collembola*) | 34 | ..... | 15 | ..... |
| Stonefly nymphs (*Plecoptera*) | 20 | 8 | 10 | 2 |
| Mayfly nymphs (*Ephemerida*) | 118 | 29 | 35 | 11 |
| Mayfly subimagos & adults | 15 | ..... | 5 | 1 |
| Dragonfly nymphs (*Odonata*) | 2 | ..... | 2 | ..... |
| Bugs (*Hemiptera*) | 27 | ..... | 18 | 1 |
| Caddis larvae (*Trichoptera*) | 26 | ..... | 22 | 2 |
| Caddis adults | 2 | ..... | 1 | ..... |
| Beetles (*Coleoptera*) | 61 | 35 | 19 | 7 |
| Midge larvae & pupae (*Chironomidae*) | 3541 | 875 | 75 | 66 |
| Midge adults | 36 | ..... | 15 | ..... |
| Blackfly larvae (*Simuliidae*) | 87 | 44 | 35 | 2 |
| Blackfly adults | 7 | ..... | 6 | ..... |
| Miscellaneous flies, larvae & adults (*Diptera*) | 170 | 22 | 44 | 3 |
| Ants, etc. (*Hymenoptera*) | 23 | ..... | 15 | 1 |
| Water mites (*Hydracarina*) | 14 | ..... | 13 | ..... |
| Spiders (*Arachnida*) | 8 | ..... | 5 | ..... |
| *Copepoda* | 307 | 44 | 28 | 1 |
| Other *Crustacea* | 4 | ..... | 1 | ..... |
| Snails (*Mollusca*) | 1 | ..... | 1 | ..... |
| Miscellaneous | 3 | ..... | ..... | ..... |

*Numbers: the figures are the total number of each kind of organism eaten by the seventy-eight trout.

Greatest Nos: the greatest number of each kind of organism eaten by one trout.

Times Occ.: the number of trout which had eaten each kind of organism.

It is apparent that the most important food organisms for the small trout were midge larvae. Only three individuals out of the total of seventy-eight had not eaten any and one individual had eaten 875. The second most important item was mayfly nymphs chiefly of the genus *Baetis* but with representatives from the *Heptageninae* and *Leptophlebia*. The

other materials while represented by relatively small percentages in the totals, yet in individual cases often formed the bulk of the food taken. It is interesting to note the occurence of *Copepoda.* These consisted largely of *Cyclops* but also of *Canthocamptus* and they were taken chiefly in the month of May. The *Hemiptera* were represented chiefly by *Aphidae* and *Rhagovelia;* the beetles by larvae of *Dytiscidae* and small adults of *Hydrophylidae* and *Staphylinidae;* the miscellaneous *Diptera* by larvae of *Dixidae, Psychodidae, Tipulidae, Syrphidae, Stratiomyiidae* and *Culicidae* and adults of *Mycetophilidae, Leptidae, Cecidomyiidae, Empididae* and *Anthomyiidae;* the *Hymenoptera* by small ants, chalcids and bees.

These small trout were taken between the dates May 1 and Sept. 13 and during this period there appears to be little change in the character of the food. The fact that the *Copepoda* were largely taken in May may have been because of locality rather than season.

The figures show that 87 per cent of the food by volume of these trout was taken in water while 13 per cent was taken from the surface.

Table 2. Food of 77 individuals, speckled trout, 2-4 inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Spring Tails | 3 | — | — | — |
| Stonefly nymphs | 34 | 9 | 15 | 3 |
| Mayfly nymphs | 295 | 54 | 50 | 22 |
| Mayfly subs. & adults | 248 | 214 | 16 | 10 |
| Dragonfly nymphs | 1 | — | — | — |
| Grasshoppers (*Orthoptera*) | 17 | — | 13 | 20 |
| Bugs | 106 | 7 | 46 | 3 |
| Caddis larvae & pupae | 225 | 28 | 46 | 10 |
| Caddis adults | 6 | — | — | — |
| Caterpillars (*Lepidoptera*) | 9 | — | 7 | 1 |
| Beetles | 93 | 7 | 43 | 7 |
| Midge larvae & pupae | 386 | 43 | 56 | 5 |
| Midge adults | 85 | 52 | 11 | 1 |
| Blackfly larvae & pupae | 167 | 80 | 17 | 3 |
| Blackfly adults | 2 | — | — | — |
| Misc. flies | 361 | 55 | 51 | 5 |
| Ants, etc. | 160 | 20 | 45 | 4 |
| Water mites | 32 | 6 | 18 | — |
| Spiders | 32 | 3 | 26 | — |
| *Crustacea* | 8 | — | 5 | 1 |
| Snails | 2 | — | — | — |
| Fish | 1 | — | — | 1 |
| Misc. | 15 | — | — | 2 |

For this group of trout, mayflies constituted the most important food item. Nymphs of the genus *Baetis* were probably the most commonly taken and the following genera were also represented: *Ecdyonurus, Heptagenia, Iron, Ephemerella, Leptophlebia, Caenis, Hexagenia.* Adults of a number of these genera occurred and in addition adults of *Tricorythus* of which 214 specimens were counted in one stomach. Grasshoppers and crickets formed the second important group and caddis larvae the third. The remaining groups constituted 38 per cent of the food taken. The bugs were represented by *Aphididae, Jassidae, Corixidae* and *Gerridae;* the beetles by *Carabidae, Dytiscidae, Gyrinidae, Hydrophilidae, Staphylinidae, Lampyridae, Ipidae;* the flies by *Dixidae, Psychodidae, Tipulidae, Mycetophilidae, Stratiomyiidae, Tabanidae, Empididae, Syrphidae, Platypezidae, Leptidae, Muscidae;* the *Hymenoptera* by ichneumons, chalcids, cynipids, ants and bees; the *Crustacea* by *Asellus, Hyalella* and small crayfish. A very small amount of fish remains was found in one stomach. The miscellaneous items included annulate worms, millipedes, *Sialis* and *Chauliodes.*

These trout were taken between the dates April 27 and October 1 and there appears to be no change in the character of the food during the period. Approximately 60 per cent of the food by volume was taken in the water and 40 per cent from the surface.

Table 3. Food of 64 individuals, speckled trout, 4-6 inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Spring Tails | 6 | — | — | — |
| Stonefly nymphs | 21 | 8 | 11 | 2 |
| Stonefly adults | 9 | — | — | — |
| Mayfly nymphs | 190 | 28 | 38 | 12 |
| Mayfly subs. & adults | 83 | 44 | 19 | 4 |
| Dragonfly nymphs | 9 | — | — | — |
| Grasshoppers, crickets | 33 | 4 | 16 | 16 |
| Bugs | 125 | 15 | 39 | 2 |
| Caddis larvae & pupae | 188 | 31 | 43 | 9 |
| Caddis adults | 7 | — | — | — |
| Caterpillars | 18 | 8 | — | 1 |
| Beetles | 69 | 17 | 45 | 5 |
| Midge larvae & pupae | 80 | 13 | 24 | 1 |
| Midge adults | 111 | — | 14 | 1 |
| Blackfly larvae & pupae | 60 | 32 | 9 | 1 |
| Miscellaneous flies | 567 | 188 | 43 | 8 |
| Ants, etc. | 136 | 29 | 38 | 4 |
| Water mites | 21 | 8 | — | — |
| Spiders | 22 | — | — | — |
| *Crustacea* | 8 | — | — | — |
| Snails | 3 | — | — | — |
| Fish | 1 | — | — | 4 |
| Miscellaneous | 16 | — | — | 1 |

Grasshoppers constituted the bulk of the food of this group of trout, with mayflies, caddis larvae and flies forming important items. The mayflies were represented by the following genera: *Hexagenia, Ephemera, Ecdyonurus, Ephemerella, Baetis;* the bugs by *Membracidae, Cercopidae, Jassidae, Psyllidae, Aphididae, Saldidae, Hydrobatidae;* the beetles by *Carabidae, Dytiscidae, Gyrinidae, Staphylinidae, Parnidae, Buprestidae, Elateridae, Lampyridae, Chrysomelidae, Ipidae, Curculionidae, Scarabaeidae*; the flies by *Culicidae, Tipulidae, Blepharoceridae, Bibionidae, Stratiomyiidae, Tabanidae, Empididae, Dolichopodidae, Platypezidae, Tachinidae, Anthomyiidae,* the *Hymenoptera* by sawflies, ichneumons, gall gnats, ants, bees and wasps; the *Crustacea* by *Asellus, Hyalella* and small crayfish. The miscellaneous items included millipedes, centipedes, *Chauliodes, Panorpidae.* The remains of a small fish were found in one stomach.

The trout were captured between the dates April 27 and September 13. There is a distinct decrease in the amount of terrestrial organisms taken during the latter part of August and in September except for grasshoppers. The great bulk of the food, 65 per cent by volume, was taken by these trout from the surface of the water.

Table 4. Food of 13 individuals, speckled trout, 6-8 inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Stonefly nymphs | 7 | ..... | 2 | 1 |
| Mayfly nymphs | 16 | 9 | 6 | 2 |
| Mayfly subs & adults | 75 | 55 | 3 | 8 |
| Dragonfly nymphs | 1 | ..... | 1 | ..... |
| Grasshoppers & crickets | 8 | ..... | 4 | 20 |
| Bugs | 36 | 20 | 6 | 2 |
| Caddis larvae & pupae | 41 | 12 | 8 | 4 |
| Caddis adults | 2 | ..... | 2 | ..... |
| Caterpillars | 45 | 42 | 5 | 12 |
| Beetles | 36 | 9 | 9 | 6 |
| Midge larvae & pupae | 20 | 8 | 6 | ..... |
| Blackfly larvae | 2 | ..... | 2 | ..... |
| Misc. flies | 87 | 55 | 8 | 3 |
| Ants, etc. | 27 | 11 | 7 | 2 |
| Spiders | 4 | ..... | 3 | ..... |
| *Crustacea* | 4 | ..... | 3 | ..... |
| Fish | 4 | ..... | 3 | 35 |
| Misc. | 6 | ..... | ..... | ..... |

In the food of this group, fish take first place in percent volume with grasshoppers, caterpillars and mayflies constituting the remaining important items. The various groups were

represented by the usual forms and need not be listed. The fish were taken from June 25 to Sept. 13. Approximately half the food of this group of trout was secured from the water and half from the surface.

Table 5. Food of 10 individuals, speckled trout, 8-10 inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Stonefly nymphs | 10 | 3 | 6 | 1 |
| Stonefly adults | 1 | ---- | ---- | ---- |
| Mayfly nymphs | 75 | 21 | 9 | 10 |
| Mayfly subs & adults | 4 | ---- | 2 | ---- |
| Dragonfly nymphs | 1 | ---- | ---- | ---- |
| Grasshoppers | 3 | ---- | ---- | 6 |
| Bugs | 24 | 23 | 2 | 1 |
| Caddis larvae & pupae | 139 | 36 | 9 | 13 |
| Caddis adults | 1 | ---- | ---- | ---- |
| Beetles | 19 | 17 | 3 | 2 |
| Midge larvae & pupae | 111 | 62 | 8 | 2 |
| Blackfly larvae | 1 | ---- | ---- | ---- |
| Misc. flies | 71 | 18 | 8 | 2 |
| Ants, etc. | 35 | 31 | 4 | 2 |
| Spiders | 3 | ---- | ---- | ---- |
| *Crustacea* | 1 | ---- | ---- | 1 |
| Fish | 6 | 2 | 4 | 43 |
| Misc. | 4 | ---- | ---- | 15 |

Fish again constitutes the most important food item in percent volume in this group,—the largest of the brook trout taken. The fish were apparently dace and sculpins.

The item in the miscellaneous group causing the high percentage there was a medium sized salamander. Mayfly nymphs and caddis larvae are the only other items forming fairly large percentages. Because of the taking of fish and the salamander, the percentage by volume of the food taken in the water was high, namely, approximately 85 per cent. The trout were taken in May and early June.

The following table gives a summary in percent volume of the food taken by the five groups.

Table 6. Summary of Food of the Speckled Trout.

| Length of Trout | Insects water | Insects Surface | Invert. (Misc.) | Fish | Misc. |
|---|---|---|---|---|---|
| 0-2 | 84 | 13 | 2 | 0 | 1 |
| 2-4 | 55 | 40 | 2 | 1 | 2 |
| 4-6 | 27 | 65 | 2 | 4 | 2 |
| 6-8 | 16 | 46 | 1 | 35 | 2 |
| 8-10 | 29 | 13 | 0 | 43 | 15 |

This table doubtless gives a fairly accurate picture of the normal changes in the character of the food during the growth of speckled trout inhabiting streams in central New York State. The young trout live in the headwaters in small rivulets, taking practically all their food from the water and feeding largely upon midge larvae. As the fish increase in size they take more and more materials from the surface. When they reach a length of about six inches they add small fishes to the diet. Thereafter fishes constitute a very important item in the diet although insects both aquatic and terrestrial continue to form a large proportion of the food.

BROWN TROUT

The brown trout material is not extensive but consists of 16 individuals from 2 to 12¼ inches in length. These fall naturally into two groups, namely, that of 7 individuals 2 to 3 inches in length and 9 individuals 5 to 12 inches in length.

Table 7. Food of 7 individuals, brown trout, 2-3 inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Stonefly nymphs | 1 | — | — | — |
| Mayfly nymphs | 57 | 24 | 6 | 34 |
| Grasshoppers | 1 | — | — | 10 |
| Bugs | 7 | — | 3 | 1 |
| Caddis larvae & pupae | 72 | 42 | 6 | 31 |
| Beetles | 10 | — | 3 | 7 |
| Midge larvae & pupae | 34 | 8 | 7 | 5 |
| Midge adults | 2 | — | — | — |
| Blackfly larvae | 26 | 23 | 2 | 5 |
| Misc. flies | 7 | — | 3 | 1 |
| Ants, etc. | 1 | — | — | — |
| Spiders | 1 | — | — | — |
| Snails | 7 | 5 | 2 | 4 |
| Misc. | 1 | — | — | — |

The bulk of the food of the small brown trout consists of mayfly nymphs and caddis larvae and approximately 80 per cent of the food is obtained in the water. The fish were taken on May 12, July 24 and Sept. 8 and 12.

Table 8. Food of 9 individuals, brown trout, 5-12 inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Stonefly nymphs | 1 | — | 1 | — |
| Stonefly adults | 2 | — | 1 | — |
| Mayfly nymphs | 18 | 10 | 5 | 2 |
| Mayfly subs & adults | 101 | 100 | 2 | 5 |
| Dragonfly nymphs | 1 | — | — | — |

| | | | | |
|---|---|---|---|---|
| Dragonfly adults | 1 | ---- | ---- | ---- |
| Grasshoppers | 48 | 26 | 4 | 80 |
| Bugs | 7 | ---- | 5 | ---- |
| Caddis larvae and pupae | 54 | 27 | 6 | 4 |
| Caterpillars | 2 | ---- | ---- | ---- |
| Beetles | 20 | 9 | 7 | 2 |
| Midge larvae & pupae | 12 | 8 | 3 | ---- |
| Misc. flies | 18 | 7 | 7 | ---- |
| Ants, etc. | 12 | 4 | 5 | ---- |
| Spiders | 3 | ---- | 3 | ---- |
| Snails | 21 | 19 | 3 | 2 |
| Misc. | 5 | ---- | ---- | ---- |

The important food materials of the larger brown trout appear to be grasshoppers and crickets and 95 per cent of the food was secured from the surface. In the food of these trout the mayflies were represented by: *Ephemera, Ephemerella, Tricorythus, Baetis; the* grasshoppers, etc, by *Melanoplus femur-rubrum, Tettigidea lateralis parvipennis, Conocephalus fasciatus, Chorthippus curtipennis, Nemobius fasciatus, Gryllus;* the bugs by *Membracidae, Jassidae, Psyllidae, Aphididae, Gerridae*; the beetles by *Dytiscidae, Hydrophilidae, Cerambycidae, Ipidae, Curculionidae;* the flies by *Tipulidae, Stratiomyidae, Dolichopodidae; Hymenoptera* by ichneumons and ants; miscellaneous by *Gordius,* millipede, water mite. The trout were captured May 11 and 12, June 1, Sept. 8, 12, 13, 27.

## RAINBOW TROUT.

Only 15 rainbow trout, ranging in size from 4 to 6¾ inches were taken. These were secured on the following dates: July 12, 18, 21, Aug. 13 and Sept. 27.

Table 9. Food of 15 individuals, rainbow trout, 4-6¾ inches in length.

| Food organisms | Numbers | Greatest Nos. | Times Occ. | Per cent Volume |
|---|---|---|---|---|
| Stonefly nymphs | 8 | 2 | 6 | 1 |
| Stonefly adults | 2 | ---- | 1 | ---- |
| Mayfly nymphs | 202 | 70 | 13 | 29 |
| Mayfly subs & adults | 8 | 4 | 4 | 1 |
| Grasshoppers | 6 | 4 | 3 | 16 |
| Bugs | 147 | 45 | 13 | 5 |
| Caddis larvae & pupae | 46 | 8 | 12 | 5 |
| Caddis adults | 4 | 4 | 1 | ---- |
| Caterpillars | 11 | 4 | 5 | 3 |
| Beetles | 142 | 115 | 13 | 22 |
| Midge larvae & pupae | 19 | 7 | 6 | ---- |
| Blackfly larvae | 3 | ---- | 3 | ---- |
| Misc. flies | 83 | 22 | 14 | 3 |
| Ants, etc. | 54 | 26 | 11 | 2 |

| | | | | |
|---|---|---|---|---|
| Mites | 7 | 2 | 6 | —— |
| Spiders | 8 | 3 | 5 | —— |
| Crayfish | 3 | —— | 3 | 8 |
| Snails | 2 | —— | 1 | —— |
| Miscellaneous | 11 | —— | —— | 2 |

The alimentary tracts of these rainbow trout contained a greater total bulk and a greater variety of organisms than did those of the other two species. It would appear that of aquatic organisms, mayfly nymphs constitute the most important item in the food and surface insects amount to approximately 53 per cent by volume. The stoneflies were represented by *Pteronarcys, Perla;* the mayflies by *Leptophlebia, Chirontonetes, Baetis;* the grasshoppers by *Melanoplus, Nemobius;* the bugs by *Membracidae, Aphididae, Pentatomidae, Hydrobatidae;* the beetles by *Carabidae, Staphylinidae, Elateridae, Cerambycidae, Chrysomelidae, Scarabaeidae, Ipidae;* the flies by *Tipulidae, Blepharoceridae, Asilidae, Dolichopodidae, Syrphidae, Platypezidae;* the *Hymenoptera* by sawflies, bees, ants; the miscellaneous by centipedes, millipedes, *Chauliodes.*

Crayfish may form an important food item of all three species of trout in some localities. In the case of the rainbow trout, one specimen was definitely identified as the common stream crayfish, *Bartonius robustus.*

## THE FOOD SUPPLY IN THE STREAMS.

It is apparent that the various organisms in the streams constitute the basic food supply for the trout. In any stream under natural conditions, or nearly so, mayfly nymphs, stonefly nymphs, caddis larvae, beetles and beetle larvae, dipterous larvae (particularly midge larvae), some *Crustacea, Mollusca* and fish are always available and must form the only source of whatever food may be taken during late autumn, winter and early spring. During the warmer months large numbers of terrestrial forms fall into the streams and constitute a very large percentage of the food of the trout. The bulk of this food consists of insects with the addition of a few spiders, millipeds, and centipedes.

Many of these insects are those whose immature stages are spent in the water, such as stoneflies, mayflies, caddis flies, midges, blackflies, etc. It would appear therefore that a stream under natural conditions will produce sufficient food materials in itself, to support a large trout population.

In other words a stream may be in this respect practically a closed system. The microscopic algae, chiefly diatoms, constitute the basic food supply of insect larvae, snails, etc. Some

of these invertebrates feed upon the rich algal growth on the stones and rocks to which they cling; others by means of special straining devises or by means of finely spun nets, catch the minute forms being carried down-stream by the current. These are the forms which are largely herbivorous and include mayfly nymphs, caddis larvae, midge larvae, blackfly larvae, snails, etc. There are others which are largely carnivorous feeding upon their associates as do stonefly nymphs, dragonfly nymphs, sialid larvae, some beetle larvae, etc. All in turn constitute the main food supply of the trout, either in their aquatic stages or in their terrestrial stages while dancing over the surface of the stream or when falling upon the surface. Here it may be pointed out that the deleterous effects of pollution are often not directly upon the trout but upon the food supply. Any substance which destroys a part of the food chain will be detrimental to the trout.

Little is known of the fundamental facts regarding stream productivity. Undoubtedly the character and abundance of the food supply is a resultant of a combination of the physiochemical characteristics of the stream but our knowledge of the factors such as geological formation, velocity, temperature, light, oxygen, hydrogen-ion concentration, etc, in relation to productivity is very limited. Before cultural methods can be intelligently applied to streams, the same intensive study must be applied to streams as is now being devoted to lakes.

General observation would seem to indicate that a stream to be productive of trout must flow through territory mostly wooded for thereby low water temperatures are maintained with accompanying high oxygen content. Turbulent streams do not require shade to the same degree because a high oxygen content is maintained by the tumbling waters. In forested areas a good stream flow is maintained through out the year and freshets are less severe and seldom destructive of the food organisms of the streams. There are, in Oneida County, streams which once were highly productive of trout but which are now entirely barren because through the removal of the forests the streams are so subjected to floods and droughts that not even aquatic insects are able to maintain an existence. Furthermore, a stream in a wooded area usually has in it fallen tree trunks which form small dams and thereby pools, falls and eddies all of which contribute to the formation of optimum environmental conditions. In addition "holes" are formed under the banks by reason of the tree roots helping to hold part of the bank in place in contrast to cleared sections

where banks are continually crumbling and adding smothering sediments to the stream's bed.

In view of the extent of the occurrence of meadow insects such as grasshoppers, grass-bugs, etc., in the trout stomachs, it would further appear that short open stretches of such length as not to result in excessive rise in the temperature of the water are advantageous in that large numbers of terrestrial insects fall into the water, are carried down stream and provide a very important food supply for the trout.

In summary then it may be said that a stream truly productive of trout is one which rises from springs in the forested uplands, flows down through wooded valleys and then through alternating wooded or meadow sections in the lowlands. In such are found adequate spawning sections toward the headwaters, relatively low temperatures with associated high oxygen content (Hathaway, 1927), abundant food supply, suitable habitats and but little competition from other species of fish.

## SPECKLED, BROWN AND RAINBOW TROUT RELATIONS.

It is apparent that in the streams of Oneida County, the food of these three species is essentially the same. Although the number of brown and rainbow trout stomachs examined was relatively small, it is interesting to note that in not even one of the thirty-one was there any evidence that fish had been eaten. It is quite probable that these species are not any more piscivorous in their diets than is the speckled trout. Embody (1922) records instances where speckled and brown trout occur together in streams without apparently being antagonistic. There is some indication that the larger brown trout take more food from the surface than do speckled or rainbow trout.

## FISH ASSOCIATES AND COMPETITORS OF TROUT.

In a stream in its natural condition, that is, little if any changed by human agencies, the fish associates of speckled trout are few. These are sculpins (*Cottus sp?*), horned dace, (*Semotilus atromaculatus*); black-nosed dace, (*Rhinichthys atronasus*); and to some extent, common sucker (*Catostomus commersonnii*). These are competitors for food and may conceivably eat some of the eggs of speckled trout although convincing proof of destructiveness in the latter respect is lacking. On the other hand, these fish are eaten to some extent by the trout. In those streams where there has been a departure from the original conditions other fish have come in. The

following have been taken in Oneida County in streams in which speckled trout also have been taken: *Campostoma anomalum, Pimephales promelas, Chrosomus erythrogaster, Hyborhynchus notatus, Leucosomus corporalis, Clinostomus elongatus, Notemigonus crysoleucas, Notropis whipplii, Notropis cornutus, Rhinichthys cataractae, Exoglossum maxillingua, Eucalia inconstans, Percopsis omisco-maycus, Boleosoma nigrum, Catonotus flabellaris,* and undoubtedly others occurred. It is apparent that speckled trout in such streams must meet very strong competition for food and this may account in part for their occurrence in limited numbers. Incidentally it may be pointed out that it is the aim of anglers to take trout and to avoid taking chubs and shiners and so intensive angling is working in the same direction as changing environment, that is, against trout and in favor of the competitor fish. There is some evidence indicating that brown trout are less interfered with by competition possibly partly because of securing a large proportion of food from the surface as previously pointed out. It is possible also that under certain conditions they may feed to a considerable extent upon their competitors (Greeley 1927). On the other hand the investigations of White (1924) appear to indicate that competitor fish may be responsible under certain conditions for considerable losses among planted trout fry.

The inter-relations of trout and their fish associates must be thoroughly studied before a definite policy in this regard can be laid down.

## THE STREAM PROBLEM.

The problem which confronts those interested in and concerned in trout culture is that of maintaining trout in those streams which flow through areas where the forests have been largely removed and where stream conditions no longer provide optimum conditions for trout. The condition is one of changing environment and the question is what can be done? Can the original environment be restored entirely or in part? Can trout be maintained with some degree of success under the changed environmental conditions by following certain fish cultural measures? Or must most of our trout cultural operations be eventually discarded and nature left to take her course? It has become evident that detailed study must be given to the problem in all its phases. At least two lines of investigation are being followed, one, as for example in New York State, where under the auspices of the Conservation Commission extensive and detailed surveys are being made for the

purpose of determining which streams will support trout and of preparing detailed recommendations as to the places where planting should be done and the extent of such planting (Embody 1922-1927, Moore 1926-1927, Clemens 1917, etc.); another, in Canada, where under the auspices of the Biological Board of Canada intensive studies are being made of very limited portions of streams where plantings of trout are being made and the extent and causes of losses are being determined (White, 1924-1927).

The results of all these studies indicate at least that trout culture in the future must become more intensive if it is to meet the situation. Each stream or river system must be studied and if found capable of supporting trout and amendable to practicable measures, it must be cultivated. Only upon the results of detailed studies of the streams and of the organisms existing in them, including the trout, can a rational system and practice be built up. Trout culture can no longer cease its work at the hatchery trough but must be carried out to the stream. A most fascinating and important field lies open to trout culturists.

The writer is greatly indebted to the following for indentifications: Dr. A. H. Eames (plants), Prof. A. G. Huntsman (*Crustacea*), Prof. E. M. Walker (*Orthoptera* and *Odonata*), Mr. J. R. de la Torre Bueno (*Hemiptera*) Dr. C. T. Vorhies (*Trichoptera*), Dr. C. P. Alexander (*Tipulidae*), Dr. O. A. Johannsen (other *Diptera*), Mr. Bryant Walker (*Mollusca*), Dr. A. G. Ruthven (salamanders), Dr. R. C. Osburn and Prof. J. R. Dymond (fish).

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MR. P. VIOSCA (Louisiana): I would like to ask Dr. Clemens if he has found any indication of cannibalism among the trout during his investigations.

DR. CLEMENS: No, not in the stomachs that we examined. The fish that were eaten were sculpins, dace, and other species, but no trout had been eaten.

DR. C. M. FRAZER (British Columbia): I would like to ask if Dr. Clemens is sure that the change of diet in the older speckled trout was due to the matter of choice, or whether there was a change in the supply. Is there a possibility that the arthropoda had disappeared and that they were eating the fish instead?

DR. CLEMENS: All material was collected in the summer, when the insect life was at its height, both in the streams and in flight. I believe that as the trout became larger they naturally took to a small fish diet. In one case the fish had eaten salmonidae. It is bulky, more concentrated material than insects.

DR. R. E. FOERSTER (British Columbia): I would like to inquire whether in the case of a barren lake in which the plankton food is plentiful, the fish when they reach a certain stage where they could subsist on a fish diet remain at a constant size, unable to increase their growth on a plankton diet.

PROF. DYMOND (Toronto, Canada): I do not think there are any lakes where the food material available to fishes is confined to plankton and fish. You have a gradation from plankton through the smaller or larger organisms up to fish.

MR. S. B. LOCKE (Utah): In that connection you might be interested in some results we have had in cooperation with Mr. Keil in stocking barren lakes of this type with trout. The growth is very rapid on the abundant plankton, but when they get up to spawning age there is a sudden decline in growth and a period of non-development after spawning, due apparently to the small types of food on which they have to depend. In connection with the question of choice, I might refer to the studies in Fish Lake, Utah, the results of which were published in "Ecology" last October. These studies indicated that when you had in that lake a flight of May flies there was a turning away from the ordinary available crustacean food, which in

that case was largely Daphnia. In this particular lake large specimens of rainbow and eastern brook trout depend for food largely upon Daphnia, but when any other food such as May flies, becomes available we find that they turn immediately to the new food, indicating that they were rather forced to depend on the Daphnia.

MR. TITCOMB (Connecticut): May I ask to which species has reference?

MR. LOCKE: Both the rainbow and the eastern brook trout.

MR. TITCOMB: In the same lake?

MR. LOCKE: In the same lake.

MR. TITCOMB: You did not find cannibalism among them?

MR. LOCKE: No, there were some fish remains, but the only other available fish besides cut-throat trout were a few little bullhead.

MR. TITCOMB: Mr. Dunstan, you had some experience in this section in connection with the planting of barren lakes. Could you tell us your results and whether you found that the fish developed well on the minute animal life in the absence of all forage fish?

MR. DUNSTAN: We have a few barren lakes. I can refer specifically to a body of water high up in the hills, known for twenty years to have had absolutely no fish at all. Rainbow fry which were put in there came up from 3,400 to the pound to 1,500 or 1,600 to the pound. Eastern brook fry planted in a barren lake attained a size of 15 inches in two years. The temperature of that lake in the average year would be 47° Fahrenheit, yet these fish grew in four years up to 26 inches in length, weighing six to eight pounds. The fish since then have decreased in size. Some years they run fairly well. My idea is that the food is not sufficient for the number of fish present. Even at a depth of 100 feet in that lake good fish food is present, but you seldom get fish containing any food below 50 or 60 feet. It is a very peculiar lake; it averages 110 feet in depth for about 95 per cent of its area, which leaves a very small percentage of the lake to produce any measurable quantity of food. In other lakes of 4,000 or 4,500 feet elevation we have planted eyed eggs and in three years those fish came up to 24 inches long.

In my eight or ten years of watching these developments in the locality to which I refer, I have found that the first

plantings of fish do well, but there is a lack of food in some of the high lakes on the west side. In a lake on the east side, 4,500 feet high where there is an abundance of food, the four year old fish grew to eight or ten pounds. I never saw a fish there under ten inches long. Last year we put in about 25,000 four inch fish in order to inject some new blood into the old stock.

MR. TITCOMB: You do not know whether there is cannibalism under these conditions?

MR. DUNSTAN: I would say that there is cannibalism But most of these lakes have done very well. On the sixteenth day of June, 1925, rainbow eggs were planted in the headwaters of the south fork of the Tolt River. On the third day of July of the following year, 1926, fish seven to nine inches long were caught. This summer, about July 27th, one was caught which measured nineteen inches. These trout seem to be doing well even though they are up in relatively inaccessible snow country, where the snowfall may be anywhere from three to ten feet.

MR. TITCOMB: Mr. Dunstan's evidence seems to confirm our opinion that in virgin waters there is an abundance of food and that under those conditions the fish will thrive on the native organisims. After a time they may exhaust the natural food supply, and then we may infer that they proceed to eat each other, to a greater or less extent. From the point of view of a stocking policy it is a matter of taking into consideration the danger of overstocking. I want to ask Dr. Clemens one question in reference to the forage fish which come into our streams after physical conditions are changed so that we get a higher temperature. He intimated that the presence of the forage fish might account for the shortage of trout, but under those conditions are not the forage fish important as food for the trout?

DR. CLEMENS: Yes, they may be, but I am afraid that they occur in too great abundance. I have not reported in this paper on the food of these rough fishes, as they are sometimes called, but in all cases where we examined their stomachs, particularly the horned dace and the suckers, the food was almost identical with that of the trout. The insects and the other aquatic organisms of the stream are about all they have to feed on, so there most be competition for the supply of food present in the stream. No doubt they form a certain food supply for the trout, but I am afraid that they are more than sufficient.

# THE NATIONAL FORESTS OF THE WEST AND THE FISH SUPPLY

S. B. LOCKE

*District forest inspector, U. S. Forest Service, Ogden, Utah.*

The general relationship of forests to fish life has been discussed many times and was only two years ago ably presented to the Society by Mr. Titcomb of Connecticut. On publicly owned forests this relation is or should be an administrative as well as a purely ecological one. Our western national forests covering over 150,000,000 acres are one of the largest areas of public forest under administration in the world.

Their primary purpose is the production of timber and the protection of watersheds. For the latter purpose they are ideally located since they form the key to the water systems of the entire west. All the principal streams have their sources in these forests although their lower courses are often outside the forest boundaries. A more effective measure for maintaining water conditions favorable for producing a permanent fish supply could hardly be devised.

The primary purpose of management of this vast area of land and water is to keep it continually producing valuable timber crops and to prevent erosion with its attendant evils. To obtain this purpose the prevention of fire, overgrazing and other depredations are essential.

Perhaps the Government forester's job as a technician ends with the protection of the forest and the production of a timber crop, but as a land administrator he must consider the other resources of the forests under his charge. Among these other resources are recreation features, forage, fish and game. Their highest possible productive use must be sought in so far as it does not detract from the primary use of the forests for timber production. A discussion of the development of the fish resources of the National Forests is the main object of this paper.

The mere fact that the National Forests are continually protected from fire and wholesale removal of timber protects the water supply and largely insures its purity and thus provides initially favorable conditions for fish. In addition the forest officers have certain direct duties and responsibilities which have important bearing on the fish

supply. One of these duties is to assist in the enforcement of fish and game protective laws.

However, the entire control of fish resources on the National Forests does not lie with the Federal Forest Service since legal jurisdiction over fish and game lies with various states. The function of the Forest Service must therefore, be in part one of cooperation and coordination, not only with the states, but other bureaus of the Federal Government such as the Bureau of Fisheries. As the field of the various federal and state agencies becomes better understood, more effective cooperation and better fishing will result.

Other activities of the Forest Service in connection with fishing are the furnishing of information regarding stream conditions and cooperation with state commissions, the United States Bureau of Fisheries and sportsmen's organizations in the stocking of the streams. Free permits are also issued by the Forest Service for the occupancy of land for fish cultural purposes to stock public waters. To protect fish resources the Service requires that permits for the construction of dams require compliance with the state laws regarding installation of fish ladders.

As an approximate estimate, there, are annually planted on the National Forests of the West between 35,000,000 and 40,000,000 trout at a cost, when planted, of not less than $750,000. Probably not less than 3,000,000 pounds of trout are annually taken by anglers. What this means in dollars both from the value of the catch and the expenditures of fishermen in the communities in and about the forests can be figured by anyone familiar with fish and fishermen.

There is probably a lack of appreciation on the part of some foresters of the possibility of fish production from water areas included in the National Forests and a failure by the fisherman and fish culturist to realize the importance of the national forest policy to fish production.

The entire habit of thought of the forester tends toward the development of long-term plans for handling the various forest resources. In producing a timber crop it is necessary to know many years in advance what is to be done and what the results will be. Likewise, with fish and game we must have clear cut policies for long periods into the future and a continuous effort to develop methods of carrying them out.

When consideration is given to our fish resources and we desire to develop management plans we find a woeful lack of information upon which to base them. We have been so busy in restocking streams and other pressing problems that most of the fundamental questions have lacked attention. As in forestry we have to know the potential growing capacity of different soils, trees and types of forest and how to handle them to secure best results, so in fish culture we must first know what potential fishing resources we have, and second, how to handle them. The first means careful surveys and the second must be based on biological information.

Relatively, I believe the arts of forestry and game production are farther advanced than that of fish culture. Certainly as regards the development of a future program, they are better situated. In agriculture $1.00 to each $853.00 produced is expended in investigations to develop improved methods. In forestry this expenditure, is $1.00 to $1,484.00. I am sure that it is much less than this in fish culture. There are eleven Federal Forest Experiment stations where fundamental forest research is carried out. This program will be considerably expanded under the provision of the so-called McSweeney Law, which among other things authorizes an appropriation of $150,000.00 annually for studies of the relationship between game and forests. The passage of this law resulted, to a considerable extent, from a detailed study by members of the Society of American Foresters and the preparation by them of a National program of forest research which was published by the American Tree Association. This discussed the entire matter in detail, presented a specific program and crystalized the support of all interested agencies.

As a forester intensely interested in the fish resources, I am very anxious to see a similar development which will initiate studies to make available information necessary for the proper and effective administration of the fish resources of the National Forests. Many of our lakes and streams will produce more meat per acre in fish than the most productive range grazing land, but we are only guessing when we attempt real administration of fishing waters. In restocking work many essential problems are untouched, and ecological knowledge necessary to make waters most productive is lacking. Hundreds of thousands of dollars are spent in restocking, in many cases successfully, but cer-

tainly not as successfully as would be made possible by greater knowledge of factors influencing fish life.

Whenever a program for studies is developed, there will be particular need of obtaining a correlation between the investigator and the administrator so that those studies of greatest use in administration may be undertaken first and the results of investigations made available as speedily as possible.

In proposing a remedy for this lack of fundamental information, action seems to me to be divided into two parts. One is the education of the sportsman and the public to the necessity for such investigations and the other is to bring all the interested agencies together behind a specific program for having them made.

Although several states are doing very effective work in fish investigations, I am assuming that the most logical way of securing fundamental information, particularly as applied to public lands, is by Federal appropriation. A better appreciation of the need of research and its possible aid to both commercial and game fish interests would advance the program of private, state and federal activities. I feel that we, of the American Fisheries Society, have a specific responsibility and an opportunity for leadership in this matter.

THE PRESIDENT: We appreciate this new emphasis on our fisheries problems.

# THE NUTRITIONAL REQUIREMENTS AND GROWTH RATES OF BROOK TROUT*

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*These experiments were financed jointly through grants from the Connecticut State Board of Fisheries and Game and the General Foods Corporation, represented by Mr. Clarence Birdseye, of Gloucester, Mass.

## Section I

### GROWTH OF BROOK TROUT

The growth of the animal body has occupied the attention of students of natural science as long as we can have historical records. It remains the outstanding concern of all those engaged in animal husbandry, whether they are rearing swine or trout. Dr. Mendel (1) has provided an excellent summary in his statement: "In ultimate analysis all of our material prosperity, indeed the very possibility of the maintenance of the race, depends upon the manifestation of growth".

The ideal of every fish culturist is to achieve in his products the maximum rate of growth consistent with reasonable economy in the use of feeds and the production of healthy bodies.

Since the rate of growth is the best means available at the present time for evaluating a given feedstuff, it is of real importance that we establish a standard. In three of our experiments which have been in progress for sixteen months, we have determined the growth rates upon 56 individuals. These have been reared in three groups, one fed exclusively upon raw liver and two fed upon combinations of dry skim milk and liver. Since these groups will be discussed in detail later, it is sufficient at this point to state that our growth curve is a composite of the two groups reared upon meat-milk diets. These represent the best growth we have obtained upon any ration. Since these included forty-three individuals, our growth curve is based upon their mean weights.

The growth rates of animals can be portrayed in several different ways. The usual method is to plot the increase in grams upon one ordinate with the progress of time expressed in weeks or months upon the other. This method is illus-

trated in Chart I and represents the mean growth for the forty-six trout A simpler graphic presentation, which is thoroughly explained by Chaddock (2), is obtained by using semilogarithmic paper in which time is scaled in the usual manner while

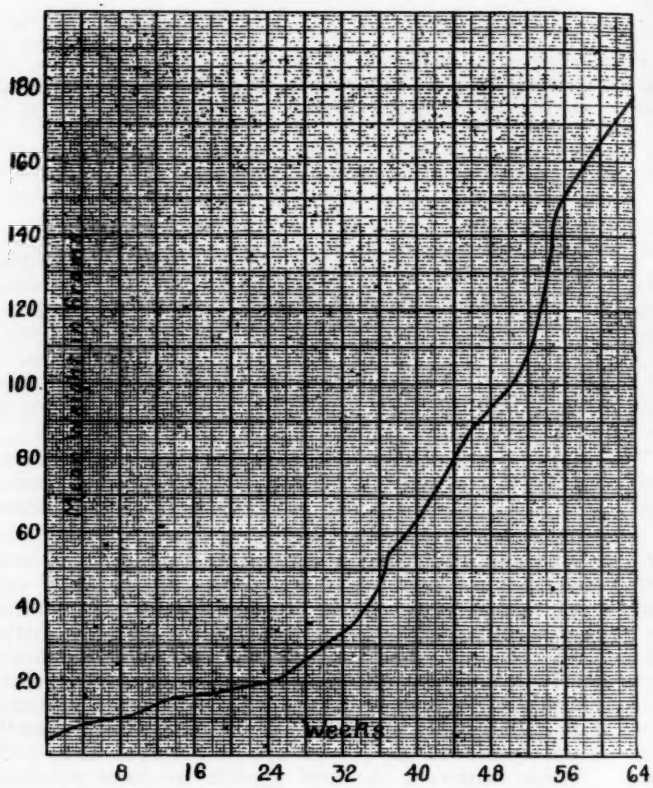


Chart I. Normal growth rate of a brook trout until the spawning period.

weight is placed upon a logarithmic scale. This method yields a better picture of the rate of growth when one is concerned primarily in comparing rates upon different feed combinations. In Chart II we have shown the rates of growth of trout, rats,

pigs, and chickens. The trout curve is constructed from the same data as that used for Chart I. The curve for the rat is based upon data from the Cornell laboratory, while those for the pig and chicken were constructed from data published by workers in Missouri (3).

Chart 2 shows quite clearly the contrast between the rapid rates of growth for the rat, chicken, and pig and the slower rate of trout. The maximum, possible growth rate attainable by any living form would be represented by a perpendicular.

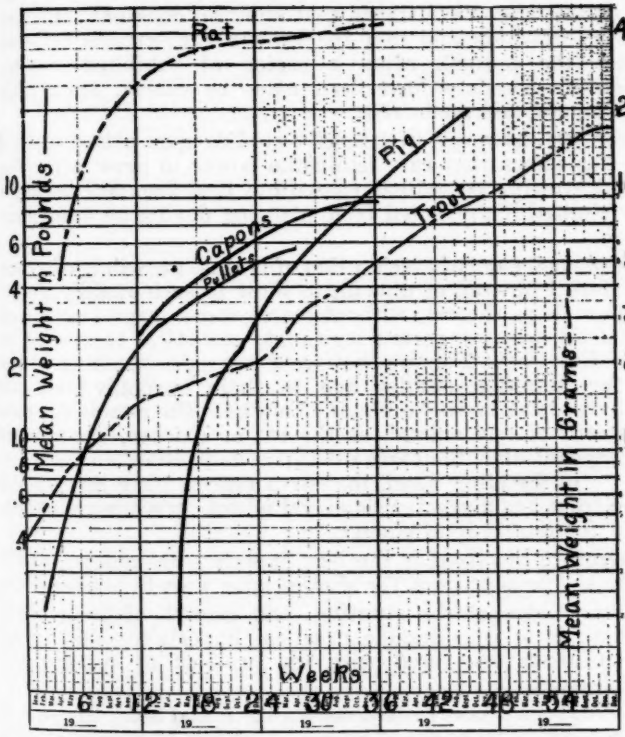


Chart 2. Comparative growth rates of the rat, pig, chicken, and trout. Weights of chicken and pig expressed in pounds, of trout and rat in grams. Weight expressed as a logarithmic function, time remaining arithmetic.

This may have been approached by the famous flies of Linnaeus (4) but, of course, was not attained.

In a previous report we have shown trout can live for long periods without growth when placed upon a faulty diet At the end of such a period of stunting, the power of growing is not lost. A regular rate is assumed as soon as an adequate diet is provided.

The problem of the resumption of growth in rats and mice, after long periods of stunting, has been studied very extensively by Osborne and Mendel and their students (5) (6) (7) (8). They have shown that stunting does not interfere with reproduction and that the growth rate attains or even exceeds the normal, after a period of inhibited growth. Similar observations have been made by others, upon rats, salamanders, and cattle (8).

Aron (9), however, in extensive studies upon both dogs and rats, has shown that rats retain the power to grow after the normal growing period has passed but that dogs are permanently stunted if prevented from growing during an analagous period.

The phenomenon of acceleration of normal growth is of unusual interest but rather difficult to show in such rapidly growing animals as the rat, without employing a large number of animals in order to permit legitimate statistical treatment of data. Our Chart 2 shows that trout are quite superior to the rat for inanition studies due to their normally slow but regular growth throughout many months. The nearer the rate of growth of any animal, as the rat or chicken, approaches the perpendicular, the more difficult it is to show an acceleration. On the other hand, the curve representing the growth of the trout has a greater slope and affords much more opportunity for the study of change.

Therefore the trout is the best experimental animal, available at the present time, for studies upon growth acceleration.

A knowledge of the stunting, and growth of trout after stunting, is of considerable practical importance since most fish culturists are faced with the problem of rearing the stunted trout.

In Chart 3 we have plotted curves 12, 1, and 30. These will be discussed in more detail later. Number 12 represents the best growth obtained upon any ration and is the same curve as that shown in Charts 1 and 2. Number 30 represents a period of stunting upon a restricted intake of raw liver, allowing just enough for maintenance during a period of twenty-

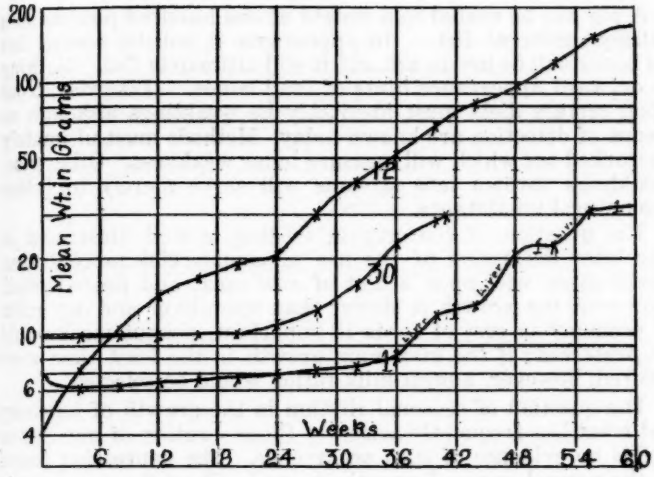


Chart 3. Growth rates of trout. Group 12 is normal. Group 30 showing growth after a period of stunting. Curve 1 showing accelerated growth after periods of stunting and alternate growth.

four weeks. At the end of this time the allowance was gradually increased until they were consuming the maximum. The rapid change in the rate shows the acceleration of growth until they reach the normal of group 12.

Curve 1 represents a group stunted upon a low protein diet for twenty-eight weeks. They were then permitted to grow until they assumed an optimum rate. After this they were stunted four weeks and this followed by growth for four weeks. This alternate stunting and growing was repeated several times. Curve 1 shows clearly the acceleration of growth after stunting periods. Although the members of group 1 were hatched from the same batch of eggs as group 12, they have failed, entirely, to spawn, thus far. While group 12 spawned at the normal season.

Three factors in the growth of trout are of outstanding importance; first, attaining a maximum growth rate or making the curve of Chart 2 as perpendicular as possible; second, the production of strong, hardy fish that can withstand natural competition; third, the attainment of a reasonably rapid growth with the cheapest possible feedstuff.

A pig can be reared to a weight of one hundred pounds on a deficient mineral diet. In appearance it will be normal but its bones will be low in ash and it will ultimately fail. Nothing in outward appearance hints of frail bones. Likewise, trout upon certain diets must inevitably be weaklings although no means of detection are known today. Methods must ultimately be worked out which will measure inner weakness. Otherwise, weaklings thrown into streams will serve merely to fatten the natural inhabitants.

The question of economy in feeding is well illustrated in our later discussion of the use of commercial concentrates. Trout grow well upon a diet of raw meat and peanut meal. However, the growth is slower than upon liver and dry milk. If economy in cost of feeds is important, peanut meal would be preferred; if the maximum growth in the least time were desired, however, a meat-milk ration would be selected.

The question of seasonal rhythm in the growth of hatchery fed trout has frequently arisen. Close scrutiny of our curves yeilds no evidence of such occurrence. The depression found in the normal curve of growth shown in Chart 2 occured when the increased size obliged us to move the groups to larger quarters. Other groups remaining in familiar quarters exhibited very little, if any, change in growth rate. The depression at the end of our curve is genuine, however, and marks the period of sexual maturity and "stripping".

The temperature of the spring water employed in all these experiments is 50° F. ± 2.5. In spite of an extreme variation of 5° F., we can detect no differences in the winter and summer slopes of our growth curves.

In any experimental work we are confronted with the adequacy of the data to answer specific questions. We feel the curves presented in these reports are reliable. The number of fish upon most of our experiments, has been fifty. In those covering long periods this number had to be decreased to twenty-five and in some cases to ten. The latter is the minimum employed and was used in only a few cases at the conclusion of an experiment. In all cases of dividing groups, we attempted a selection that would not alter the mean value.

The regularity of the increases in the mean weights of various groups suggests sufficiently large experimental numbers.

Another test of the adequacy of an experiment in nutrition is the ability to duplicate results. In Chart 4 we have shown the growth weights and mortality rates of two groups of trout fed upon skim milk supplemented with vitamins. The major

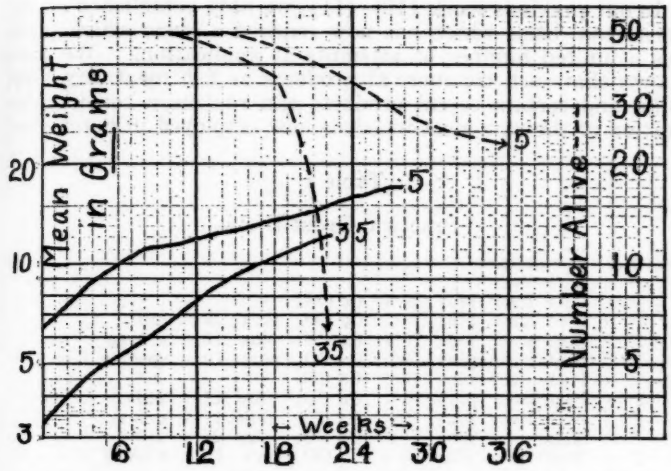


Chart 4. Growth and mortality rates of brook trout fed upon dry skim milk. Experiments carried out with fingerlings hatched from eggs of succeeding years. Semi-logarithmic Chart.

difference in these experiments is that No. 35 was carried out a year after No. 5. The trout used for No. 35 were hatched a year later. These curves are almost identical, if corrected for relative weights at the beginning of the experiment, and show that duplicate results can be obtained in succeeding years.

## Section II

### APPLIED EXPERIMENTS

In the application of scientific investigation to an industrial process, the work falls naturally into three divisions. The first is concerned with the discovery of the major facts by the use of small amounts of materials; the second employs the promising results from the first work and tries it out upon a semi-commercial scale in order to obtain data upon more animals or with considerable amounts of material; the third applies the data of the second work to the process under conditions of full scale production. Some large industries maintain three separate laboratories, each with its own staff responsible for these three distinct phases of the development.

In our previous work (10) (11), we have established an experimental basis which has now reached a stage which justifies a limited number of attempts at application. We have shown that such commercial products as fish meal, dry skim milk, and certain cereal products can replace a considerable portion of the raw meat which is now employed in hatcheries.

## Table I

### Practical Trout Diets

| Diet No. | Composition |
|---|---|
| 20—P | Beef liver |
| 9—P | Beef liver plus 75% $CaCO_3$ |
| 10—P | Beef liver plus 75% $CaCO_3$ plus 20% milk. |
| 11—P | Beef liver plus 75% $CaCO_3$ plus 10% c. l. m. |
| 13—P | Beef liver plus 75% $CaCO_3$ plus 10% spec. c. l. m. |
| 14—P | Pork liver plus 75% $CaCO_3$ |
| 15—P | Pork liver plus 75% $CaCO_3$ plus 20% milk. |
| 16—P | Pork liver plus 75% $CaCO_3$ plus 10% c. l. m. |
| 17—P | Melts plus 75% $CaCO_3$ plus 20% milk. |
| 18—P | Beef liver plus 75% $CaCO_3$ plus 15% milk, 5% c. l. m. |

In table 1 we have listed the composition of a series of rations which afford possibilities for feeding upon a large scale. These have been studied by feeding them to groups of brook trout, employing the technique described previously. Fifty fingerlings have been used in each group. They have been weighed at intervals of four weeks. The growth curves shown in Chart 5 have been constructed from the mean weights and represent the growth of the average individual upon the given ration. During these experiments involving a period of twenty-seven weeks, we have lost only two trout in the total of five hundred involved in these studies. Hence there are no mortality curves to record.

Although final decision as to the relative merits of these diets must be left for latter reports, important trends of the curves are already evident after 28 weeks of study. A close scrutiny of the curves shows no differences at the end of twelve weeks. This negative observation assumes real importance when we realize that many of the experiments upon the food requirements of trout that are recorded in the literature are the result of a summer's work. Few if any valid conclusions can be drawn from such a brief period. If conditions oblige an investigator to terminate his experiments after such a short period as one summer, he must employ large numbers of trout in each group and apply careful statistical analyses to his data before he presents conclusions.

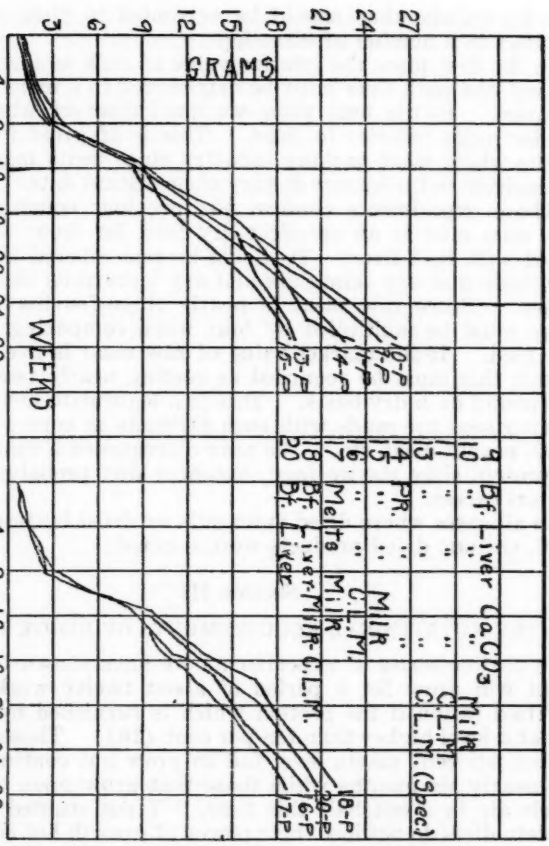


Chart 5. Growth rates of trout fed upon rations planned for practical use in the hatchery. Rations are listed in Table I.

The trend of the growth curves of Chart 5 indicate that:—(1) Beef liver, supplemented with either dry skim milk or calcium carbonate, is superior to any other of the combinations. (2) Beef liver and its combinations are superior to pork liver. (3) Cod liver meal is of no value as a supplement to raw liver. (4) Milk is less effective as a supplement to melts or pig liver than it is to beef liver.

Since these experiments are of marked practical value in determining the relative prices the fish culturist can afford to

pay for meats, they should be expanded to yield conclusive answers in a number of directions.

In the first place the relative value of milk as a supplement to beef and pork liver must be determined in a more extensive manner. In the next place we must discover what factors render melts inferior to liver. This is of great importance to the whole meat packing industry since melts may be used extensively in the human dietary at no distant date.

These experiments confirm our previous conclusions that dry skim milk is an excellent dry feed for trout when combined with beef liver. It should be remembered in purchasing feeds that dry skim milk and dry buttermilk contain little water. Since raw meat is nearly three-fourths water, its price must be multiplied by four when comparing it with a dry feed. If the market value of raw meat is five cents per pound, this must be regarded as costing nearly twenty cents per pound on a dry basis. This is a legitimate method when comparisons are made with such products as corn gluten, fish meal, peanut meal, etc. We have disregarded a consideration of protein since the average hatchery diet probably contains a great excess.

In all cases where dried skim milk or dried buttermilk were used, vacuum dried products were selected.

## Section III

### THE NUTRITIONAL REQUIREMENTS OF BROOK TROUT

In earlier series of experiments we have shown that brook trout will grow for a period of about twelve weeks upon a purified ration if the protein which is furnished by casein is fed at a level higher than ten per cent (10). Those trout fed at ten per cent casein level fail to grow but continue to live for nearly six months while those that grow upon the higher levels die in about half this time. Trout stunted upon low protein diets do not lose their power of growth but can resume a normal rate after twenty weeks of stunting if allowed an adequate diet. We have been unable to show that our failures in rearing trout upon purified rations are due to any known mineral or vitamin factors.

In the experiments recorded in this division, we have used the same technique as that described in section 2. The growth curves are constructed for the most part from weights taken at intervals of two weeks. In all cases the latter portions of the curves are constructed from weighings at intervals of four weeks. All weights are expressed in grams and time is plotted in weeks.

The compositions of the rations employed have been listed in Table 2. The numbers of the growth curves of the charts

Table II

COMPOSITION OF RATIONS EMPLOYED

| No. 1 | | No. 1-b | | No. 5. | |
|---|---|---|---|---|---|
| Casein | 10 | Raw liver | 20 | Dry skim milk | 98 |
| Starch | 82 | Diet No. 1 | 80 | Cod liver oil | 2 |
| Salt mixt | 6 | | | Yeast | |
| Cod liver oil | 2 | | | | |
| Yeast | | | | | |

| No. 11 | | No. 12 | | No. 17 | |
|---|---|---|---|---|---|
| Raw liver | 61 | Raw liver | 90 | Lactose | 50 |
| Dry skim milk | 37 | Dry skim milk | 7 | Casein | 39 |
| Cod liver oil | 2 | Cod liver oil | 2 | Cod liver oil | 2 |
| Yeast | | Starch | 1 | Salt mixt. | 9 |

| No. 18 | | No. 18a | |
|---|---|---|---|
| Casein | 10 | Raw liver | 20 |
| Starch | 85 | Basal ration "B" | 80 |
| Salt mixt. | 3 | | |
| Cod liver oil | 2 | | |
| Yeast | | | |

| No. 23 | | No. 24 | | No. 25 | |
|---|---|---|---|---|---|
| Dry skim milk | 93 | Basal ration "B" | 78 | Basal ration "B" | 83 |
| Raw liver | 5 | Raw liver | 20 | Vitavos | 15 |
| Cod liver oil | 2 | Cod liver oil | 2 | Cod liver oil | 2 |
| Yeast | | Yeast | | Orange juice | |

| No. 26 | | No. 28 | |
|---|---|---|---|
| Red dog flour | 65 | Raw liver | 100 |
| Salt mixt. A | 3 | | |
| Raw liver | 30 | | |
| Cod liver oil | 2 | | |

| No. 29 | | No. 30 | No. 31 | |
|---|---|---|---|---|
| Corn gluten | 35 | Restricted intake of raw liver. | Fish meal | 24 |
| Starch | 30 | | Starch | 41 |
| Salt mixt. A | 3 | | Salt mixt. A | 3 |
| Cod liver oil | 2 | | Cod liver oil | 2 |
| Raw liver | 30 | | Raw liver | 30 |

| No. 32 | | No. 33 | | No. 34 | |
|---|---|---|---|---|---|
| Peanut meal | 24 | Dry buttermilk | 85 | Dry buttermilk | 85 |
| Starch | 41 | Vitavos | 10 | Raw spleen | 15 |
| Salt mixt. A | 3 | Cod liver oil | 5 | | |
| Cod liver oil | 2 | | | | |
| Raw liver | 3 | | | | |

| No. 35 | | No. 36 | |
|---|---|---|---|
| Dry skim milk | 85 | Dry skim milk | 85 |
| Vitavos | 10 | Raw melts | 15 |
| Cod liver oil | 5 | | |

and the diet numbers correspond. Basal ration "B" was composed of casein 35, starch 62, and salt mixture 3.

The term salt mixture means that of Osborne and Mendel (12). "Salt mixture A" is a simple mineral combination of one part calcium carbonate, one part bone meal, one part sodium chloride with a trace of potassium iodide.

The yeast employed was the concentrated, dried product. When yeast was added, it was estimated an the basis of one

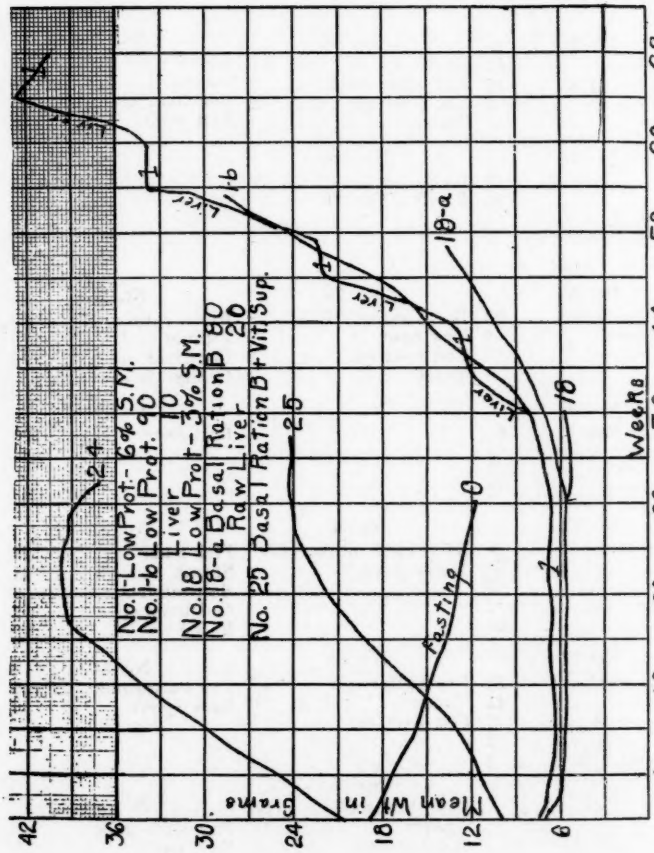


Chart 6. Curves showing fasting, alternate growth and stunting growth after long stunting, and growth upon synthetic rations. Composition of No. 24 listed in table II.

half gram per day per two hundred grams of fish. "Vitavos" was the malt product of E. R. Squibb and Sons.

## STUNTING OF BROOK TROUT AND THEIR SUBSEQUENT GROWTH.

Recently we have reported (11) :—"In our previous report we have also shown trout are stunted upon diets containing ten per cent casein and either three or six per cent salt mixture. This work has been repeated and extended over a much longer period to determine whether trout lose their power of growth after long stunting. Two groups of trout were fed for a period of twenty-eight weeks upon low protein diets, Nos. 1 and 18 respectively. The average growth curves (Chart 6) of individuals of these groups show that there was no growth throughout this entire period. Since the death rate started to increase rapidly at the end of twenty-eight weeks' period, each group was divided. Half of eighteen was continued upon the previous diet. As shown in Chart 6, these all died in the course of another eight weeks.

Half of group one was changed to diet 1-b which is merely the previous ration No. 1 supplemented with 20 per cent raw liver. Although the members of this group had remained at an average weight of seven grams for twenty-eight weeks, they had not lost the power of growth since in the next fifteen weeeks they resumed a normal rate and attained an average weight of twenty-nine grams.

Likewise the other half of group eighteen was transferred to diet 18-a which also permitted growth. In both cases there was some mortality after the transfer. We have constantly observed that the death rate is not immediately checked by transfer from a poor to a good ration. The growth upon rations 1-b and 18-a is shown in Chart 6. These experiments not only show that trout do not lose their power of growth after being stunted for a period of nearly seven months but also indicate that there is nothing in diets No. 1 and basal diet B which inhibits growth. Curve 24 of Chart 6 yields further evidence that basal ration B was not toxic since it permitted quite normal growth over a period of twenty weeks when it was supplemented with raw liver.

In curve O of Chart 6 we have shown the weight losses for a group of fasting trout. This shows a gradual loss of weight in contrast to the constant weight of the group upon the low protein diets after the latter had suffered an initial loss. From this we may conclude that those trout fed the low protein ra-

tions do not fast but consume just about enough food to maintain their body weights without any increase. It appears that trout eat for calories and not protein.

The remaining halves of group 1 and 18 were pooled at the end of thirty weeks. In the course of the next six weeks they were gradually transferred from their previous rations to one of raw liver. For the next four weeks they were allowed to grow upon raw liver, consuming all they wished. At the end of this period they were again placed upon liver diet and allowed to grow. We have thus obtained alternate periods of growth and stunting. This is shown in the curve which is the continuation of No. 1 of Chart 6. The growing periods are marked "liver" while the stunting periods are marked "1". After the initial losses, there have been few deaths under this regime. This experiment of alternate stunting was undertaken originally to provide an experimental proof that the rings upon the scales of fish are indices of their age.

Curves 1-b and 18-a of Chart 6 show that growth can be obtained upon purified rations if these are supplemented with about a fourth their weight of raw meat. This is also shown by curve 24.

"In order to determine whether normal growth can be secured by employing a very large amount of Vitavos in conjunction with a purified ration, we have fed diet No. 25. This growth curve is reproduced in Chart 6. This cannot be termed a "purified ration" since it contains 15 per cent Vitavos. We have obtained a moderate growth rate over a period of twenty-eight weeks. This indicates again that the basal ration B is not toxic and affords a starting place for improved experiments with purified rations".

Ration 25, however, is still deficient because at the conclusion of the period shown by the growth curve, two-fifths of the trout had died.

In section II we have presented data showing that dry skim milk can satisfactorily replace a considerable portion of raw meat in rearing trout.

Our previous work has shown that milk alone will permit good growth for only a limited time. Combined with meat, however, it has been very successful throughout our longest experiments which cover a period of sixteen months.

In the recent work of Titus (13), he reports that milk is rendered satisfactory for the formation of blood only when supplemented with traces of such minerals as copper, iron, and manganese. Since our earlier failures with dry skim milk alone may have been due to traces of inorganic elements. we

have supplemented the milk and buttermilk of rations 33, 34, 35, and 36. To each ten pounds of the dry skim milk and dry buttermilk, we have added 0.15 grams of zinc sulfate, 0.20 grams of copper sulfate and .065 grams of ferric citrate.

Dry buttermilk was included in this series since some workers have attributed special virtues to sour milk in checking fish parasites. Dry buttermilk contains about six per cent lactic acid with its other constituents in quite the same proportions as dry skim milk.

Melts were included in these studies since the practical experiments of section 2 had shown it to be inferior to liver.

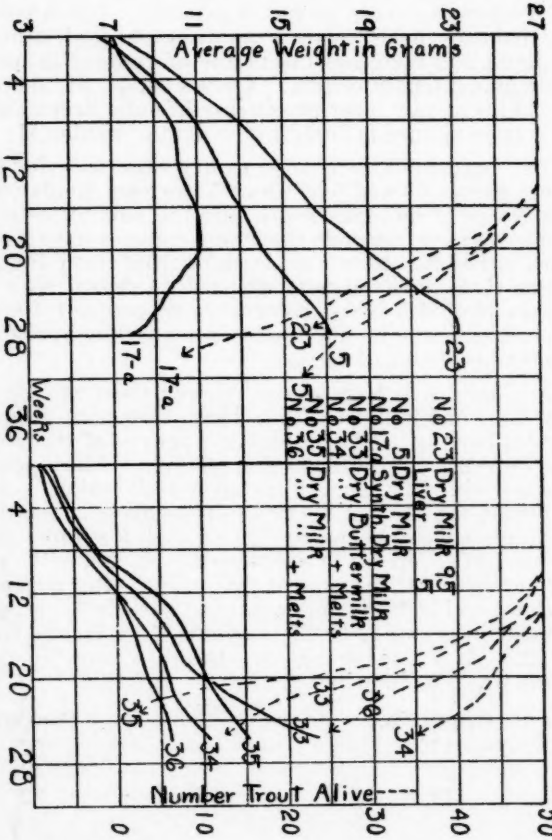


Chart 7. Growth and mortality of trout fed dry skim milk rations, dry skim milk and buttermilk supplemented with raw liver and raw melts. Curve 23, milk and liver, contrasts with 36, milk and spleen.

Both the growth curves and mortality rates upon these rations are shown in Chart 7. The growth curves show that milk or buttermilk supplemented with as much as fifteen per cent raw melts is inferior to dry products without supplementing. Curve 23 of Chart 7, however, shows the marked growth acceleration produced by an addition to dry skim milk of only 5 per cent of liver.

Melts and liver exert opposite influences upon the growth rate when they are combined with dry skim milk.

They exert the same influence, however, in lowering the mortality rate. Both raw meats increase the average length of life but liver only promotes growth. It has been suggested that raw meat, being a natural fish food, stimulates the appetite and increases the intake of feeds with an increased growth and length of life. Curves 33, 34, 35, and 36 present a picture of raw meat prolonging life and decreasing growth. The same picture is found in the data of section II.

Dry buttermilk is as good as dry skim milk for trout feed. Since curves 35 and 5 of Chart 7 are very similar, in spite of the traces of minerals added and the new vitamin B supplement, we must conclude that these changes have had no effect upon either the growth or death of trout upon dry skim milk. These data do emphasize, the points shown with the same curves plotted upon semi-logarithmic paper in Chart 4, that experiments can be duplicated in succeeding years with trout from a new batch of eggs.

In Chart 8 we have presented data from experiments upon raw liver and milk rations. These have been in progress for sixteen months. The flattening at the end of the curves shows the influence of the spawning period. These groups were started with fifty fingerlings upon each ration. At the end of twenty-four weeks, the groups were divided, and the number of trout reduced to twenty-five, in such a manner as to cause no marked difference in the mean weight and without selection for quality. At the time of this report, after sixteen months, various accidents during weighing periods have reduced the number in group 12 to 22, in group 11 to 21, and in group 28 to 12. At the spawning period the per cent females in each group was the following

| Group No. | Per cent |
|---|---|
| 11 | 52 |
| 28 | 42 |
| 12 | 32 |

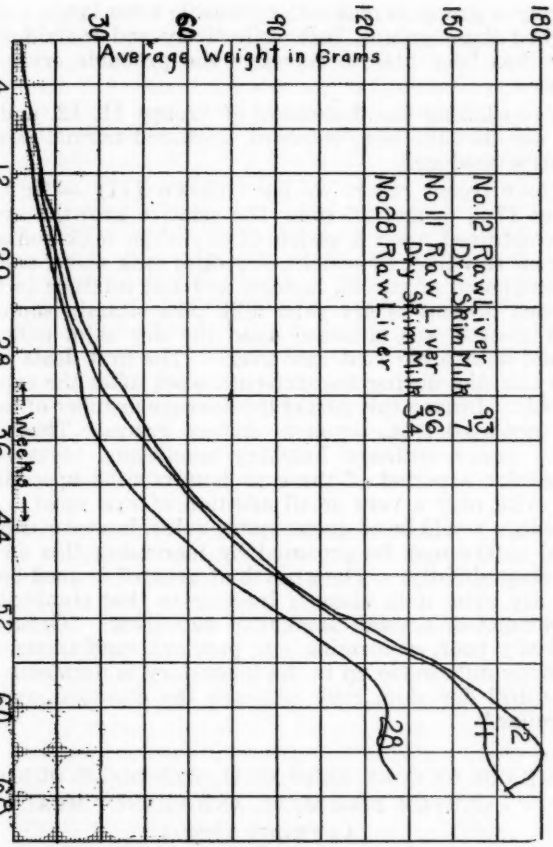


Chart 8. The growth of trout reared for a long period upon ray liver and dry skim milk compared with growth upon raw liver alone.

The flattening at the ends of curves 28, 11 and 12 occurred during the spawning period. The drop in No. 12 occurred after stripping when the trout refused to take much, if any, food.

From the appearance of the curves and from our previous reports, it seems that raw liver combined with dry skim milk is superior to raw liver alone. Such a conclusion would not be justified if it were based upon the mean weights of groups 11, 12, and 28 at the end of the experiment, because the small

number in group 28 makes the probable error large. We have weighed these groups, both collectively and individually, and have thus been able to calculate the probable error for the mean.

In concluding the discussion of groups 11, 12, and 28, we may say that the eggs obtained, appeared normal in size and quantity produced.

In our recent report we have shown (11) :—"In Chart 7, curves 17-a, 5, and 23 show the relative growths and death rates obtained upon a ration of dry skim milk containing 5 per cent raw liver by weight, dry skim milk alone, and a third one composed of casein, lactose, and salt mixture in the proportions present in dry skim milk plus vitamin supplements. Good growth was obtained upon the dry skim milk supplemented with 5 per cent raw liver. The first death occurred upon this diet during the sixteenth week after the experiment started. During this period the average member of the group had increased from seven to sixteen grams. This indicates that , under ordinary hatchery conditions, trout could be reared for a period of three to four months upon dry skim milk with only a very small addition of raw meat. Such a procedure would be of questionable value, however, since additional safety may be procured by increasing this amount of raw meat slightly. The growth of group 5 is good but shows that dry skim milk alone is inferior to that obtained with a supplement of a small amount of raw liver. Group 17-a is markedly poor, confirming our previous conclusions that the synthetic milk made up in the laboratory is decidedly inferior to natural dry skim milk although the chemical composition is similar."

## THE USE OF CORN GERM MEAL, RED DOG FLOUR, CORN GLUTEN, FISH MEAL, AND PEANUT MEAL AS TROUT FEEDS.

In these intitial studies of protein concentrates that are cheap and commercially available, we have planned our rations so that all include the same per cent of protein. Each ration also contains mineral and vitamin supplements. A simple mineral mixture was employed. This renders it relatively cheap.

Since it has been questioned whether such concentrates as corn gluten meal can have any nutritive value for trout, we were obliged to adopt a special method of testing. If we feed

one group of trout, as number 29, with a ration of corn gluten, mineral mixture, vitamin supplement, and raw liver and obtain a moderate growth, we may attribute this entirely to the allowance of raw meat and assume the other materials are inert. To check this possible error we can weigh the food consumed by No. 29 of table I as carefully as possible. The following week a check group can be fed the same amount of raw liver that was consumed by No. 29 during the preceding week. This allowance of raw liver must be adjusted to account for differences in the weights of the two groups. In case the growth of group 29 is to be attributed only to the liver they consume, the check group receiving that amount of liver minus the other ingredients should show the same growth rate. The check group of these experiments is number 30.

While the question of whether or not trout can employ the usual cereal grains for growth and maintenance may seem ludicrous to one whose experience has been restricted to the higher mammals, it is an important practical question to the fish culturist. And it becomes a legitimate consideration when one recalls the exceedingly short intestinal tract of the trout.

Table II contains the composition of the diets. Group 26 was fed a ration containing 65 per cent red dog flour; group 27 received one containing 65 per cent corn meal; number 29 was fed 35 per cent corn gluten; number 31 received 24 per cent fish meal; number 32 was fed a ration containing 24 per cent peanut meal.

The growth curves for both group 30 and those groups fed upon the various proteins, chiefly of cereal origin, are shown Chart 9. All these experiments were started with fifty members in each experimental group but since this number became too large for the available troughs, they were reduced to ten in each group. This reduction was effected with a selection that produced no alteration in the average weight. In the process of reducing the numbers, group 31 was accidentally destroyed. Therefore this curve terminates while the other experiments are still in progress.

At the end of twenty-four weeks, group 30 had shown no growth. This demonstrates quite clearly that trout can use some portion of cereal grains for either growth or maintenance. Both groups 26 and 29 displayed excellent growth. At the end of twenty-four weeks group 30 was changed to ration 31 and allowed all the food it wished. Growth was quickly resumed and proceeded at an optimum rate, showing

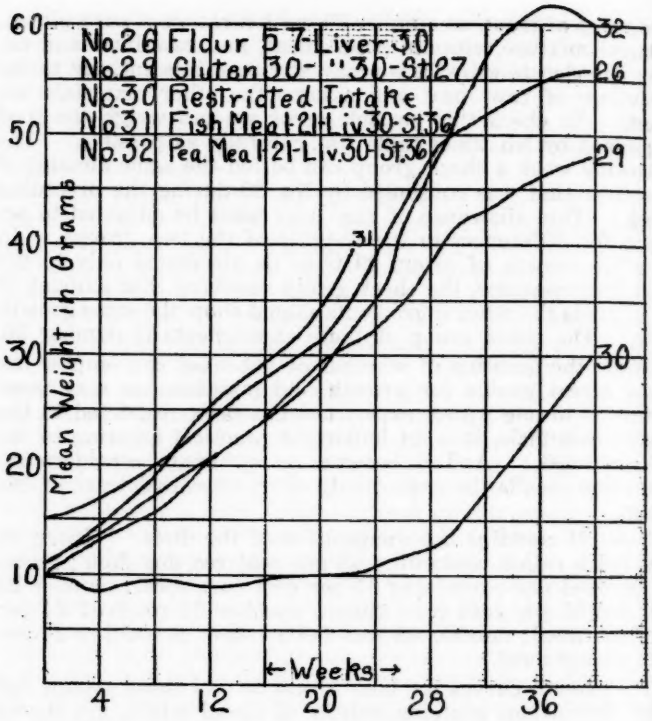


Chart 9. The growth of trout upon rations of fish meal, corn gluten, peanut meal, and red dog flour supplemented with raw liver. The contrast with the allotted intake of raw liver in ration 30 shows trout can utilize these dry feeds for growth or maintenance. The drop at the end of 32 cannot at present be accounted for.

once more that trout can be stunted for many weeks but do not lose their power of growth. This group will be followed with special interest since at the time of this report the other groups are expected to spawn. The influence of stunting upon spawning will be discussed in a latter paper.

Fish meal, corn gluten, red dog flour, and peanut meal are all capable of producing good growth in trout if they are supplemented with thirty per cent of raw liver. The minimum allowance of raw liver to produce a maximum growth

has not been determined. All these rations have been supplemented with a simple salt mixture which has been indicated. This mineral mixture has been added as a precaution rather than because any of our experiments have shown it to be essential.

Although we have experiments in progress to determine the best form of starch (raw, cooked, or dextrinized) for utilization by trout, we have no data upon this subject thus far. The feces of one group of the groups fed partly upon raw starch yielded a marked color test with iodine.

## SUMMARY AND CONCLUSIONS.

The trout shows an unusually regular rate of growth until it attains sexual maturity. This rate affords an interesting contrast to that of the chicken, pig, and rat. As a result of this slow, regular growth, the trout is an unusually fine experimental animal for studying the fundamental factors that control growth.

Experimental groups have been stunted, both by means of low protein and by a restricted intake of calories. The power to grow is retained after many weeks of stunting. In all cases, trout attain an optimum growth rate after a period of stunting and in some cases show an increased rate above our optimum.

Stunted fish upon purified rations, live considerably longer than controls allowed to grow upon similar diets. This phenomenon indicates that the trout body contains a store of some essential which is consumed in growth but necessary to life.

Dry skim milk, dry buttermilk, corn gluten, flour, peanut meal, and fish meal have yielded promising results in initial trials. These substances should replace a reasonable portion of the raw meat now used in hatcheries.

Beef liver seems superior to either pig liver or melts. Melts are not effectively supplemented by dry skim milk or dry buttermilk in contrast to beef liver.

The growth curve of the brook trout has been determined over a period of sixteen months.

Trout reared upon combinations of raw meat and dry skim milk attain a normal sexual maturity and produce normal eggs.

Trout selected for this experiment were fingerlings not less than 2 inches in length. The age may be estimated by the weight as shown at the beginning on the graphs. The graphs showing large sizes at the beginning are continuations of lots previously reported.

In conclusion we wish to thank Pryofessor L. A. Maynard and Chester D. Tolle for assistance and advice in the course of these experiments.

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*Discussion.*

MR. TITCOMB: Besides these intensive basic experiments of Dr. McCay's we have been feeding milk to a lot of our fish in one of the hatcheries, and I would like to ask Mr. Cobb to discuss that question and refer to some of the points which I may not have brought out.

MR. EBEN W. COBB: Madame President, I have not prepared anything for this discussion in the nature of a paper. Our good president said the other day that the scientist and the hatchery have been brought together. Theoretically that is true, but in actual practice the scientist and the ordinary hatchery are as far apart as they ever were, and they will have to be linked together by what you might call the wireless telephone connection. In these investigations into the matter of fish food and nutrition, that is the method which we have taken. We are not trying to make our ordinary hatchery man understand these very exact experiments carried on by Dr. McCay. When Dr. McCay has proceeded with his experiments to the point where there is something that seems good to him, that is of the right chemical constituency to give satisfactory results, then we have to consider, besides the actual cost per pound, whether the material is available in quantities, whether it can be prepared readily by the ordinary hatchery employee feeding the fish, and the cost of preparation. We have to compete with the commercial trout breeders' finished product and must keep down to that cost.

So we have a second set of small tanks similar to those used by Dr. McCay in which we carry on these experiments which you might call of a sem-practical nature. We feed the fish more as hatchery fish are fed, and from that we carry on further experiments in the hatchery. Now, this is what takes time and effort and sometimes a great deal of work. We bought beans for about a dollar a bushel. It seems cheap, but we find in actual practice that when the beans are properly prepared and mixed with the other food the cost is about the same as that of the cheaper grades of meat. As the results were not satisfactory we tried raw bean flour, which can be readily mixed. And here I believe the question of appetite came in. We gave them only 20 per cent of the bean flour, the rest meat, which should have kept the fish in good shape, but the fish would not take the bean flour; when it was mixed with the meat in such a way that they could not take the meat separately, they refused to take the meat, and when we let them go the other day they were a small undersized lot.

Another instance which I will mention is that of the vacuum dried milk. I believe that these dry products might show better results in the meat mixture solely on account of their being sufficiently absorbent to take up the juices of the meat which we sometimes otherwise lose. The basic experiments have shown that there is nourishment in the milk and that the fish take it and thrive on it. The problem was to use it in actual hatchery practice. We fed fish out of the same lot, in the same hatchery, under the same conditions, side by side, with meat alone and with meat two-thirds and dry milk one-third by weight. We found that we could mix this milk with the meat in the feed buckets up to a certain proportion quite readily; beyond that it became so dry that it would mix without making the food impossible to handle. By weights we determined how to mix this to such a constituency that the fish could eat it without losing all the milk into the water. We are now using one-half of one of our hatcheries on this experiment. We take five pounds of meat, mix two pounds of water with the meat, and then mix in two and one-half pounds of milk. These proportions make a constituency that is heavier, and somewhat firmer than the meat alone but still will mix readily. It can be placed in the water in chunks so that three inch fingerlings and over can and do take it very readily. There is no less of milk into the water. After a few weeks we found that the milk fed fish had gained 50 per cent in weight over those having meat only. The milk fed fish were very uniform in size while the meat fed fish were of various sizes. Approximately 50 per cent of the larger fish weighed almost exactly the same as the milk fed fish, and the balance were smaller. The difference in weight gained by the milk fed fish continued uniform throughout the summer. No further observations were made with the smaller meat fed fish but continued feeding the larger ones on meat. These kept up to the milk fed fish and fed on meat only. I

wish that we had carried through a few of the small ones and put some of them on milk and some on meat, but in the hurry of distribution we did not do it. This is a practical hatchery experiment.

We found that in feeding these larger fish, what they would readily take, about 50 per cent more food was required to bring about the 50 per cent increase in weight than was consumed by the fishes fed in the regular way. Milk not only costs less than meat but also effects a saving in overhead, there being no extra labour to speak of.

MR. TITCOMB: Do you not start the fry on milk?

MR. EBEN W. COBB: We started them quite small. They had been fed a short time on liver.

In almost all of our experiments we have used beef liver. Now, beef liver is getting beyond the range of our hatcheries to use, except perhaps in the very starting of the fry. I believe that the great factor in the feeding of meats is to the physical condition of the meat which makes it either possible or impossible to prepare it in such a way that the young fish can take it and get the juice as well as the meat. Beef liver is the best for fry, and it can be prepared in a fine state rather better than most other meats, except possibly beef hearts. In this experiment we compared beef liver with other meats, and we found very little difference in their relative nutritional values. If that holds true I think we will be safe in substituting the word "meats" for beef liver in the other experiments.

We do not know as much about clam heads as we do about milk, but the fish like them, take them readily, and they are very inexpensive. Moreover, they are easy to prepare and to mix with the meat diet. They can be bought in fairly large quantities and will keep almost indefinitely, they do not get damp. We are therefore experimenting with clam heads to see what the results are as compared with meat and also milk. At present we are using the clam heads and meat with no other mixture. The clam heads are dried and hard as flint. We do not want to introduce water into our meat; I believe it is apt to make the meat become sour, as we call it in the hatchery, so we mix the clam heads with water, soak them overnight so that they will be as soft as they can be without soaking them sufficiently to destroy the juices. We found by weighing that a pound of clam heads would take up one and a quarter pounds of water and not leave any water in the bucket. They are run through an Enterprise meat cutter with the meat thus mixing them together. Clam heads ground to a meal can also be obtained. For No. 3 fingerlings and for larger trout clam heads are preferable to the meal. In using the clam meal the finer particles more readily disintegrate and are lost in the water.

Concerning the use of fresh fish, I have been at commercial hatcheries where carefully selected fish is brought in frozen, dropped on the floor in the middle of the hatchery and left there to be surrounded by flies. One man I was speaking to this summer says he has absolutely no trouble in holding it for three days lying on the floor with the doors open on both sides. We have put in a freezer so that if we need any fish we can get it absolutely cold; in fact we can keep it frozen until the day we want to use it. We grind it after practically defrosting.

We do not find it practicable to feed fish to the fry, but we grind the fish for fingerlings from three to four inches long.

MR. LAIRD: May I ask Mr. Cobb whether any experiments have been made with shrimp bran, and what he thinks of its value?

MR. EBEN W. COBB: We are using some shrimp bran, but personally I have no idea of its value. I should think that shrimp bran would furnish a considerable amount of calcium, which we are getting through the use of milk and also with the sea loaf. Shrimp meal, as we have it, is composed almost entirely of shells and heads. I do not know to what extent the fish can digest it; in fact I do not know what is in it. It is a cheap product, and if wet slightly and allowed to soak a few hours it will mix very readily with the meat and go through the cutter without any difficulty. It does not add to the hatchery cost to any extent, and if the value is in the product it would be a cheap food.

MR. LAIRD: I think when you come to use the fish as food you will find, as I have found, that the virility of the eggs is gone; you do not get the quality in the eggs that you do when you feed the meat.

MR. TITCOMB: That is one of the things we propose to determine.

MR. LAIRD: In regard to the matter of keeping the food in as solid form as possible and still getting the fish to eat it, I may say that in feeding the fingerlings I do not use any water; I simply hang the food in a pan, let the edge of the pan be just under the surface, and the fish will take that solid food stuff right off. They do not get any water with it, and there is nothing wasted.

MR. KEIL: I should like to inquire about the buoyancy of this mixture of milk. Does it sink slowly, or does it settle to the bottom quickly?

MR. EBEN W. COBB: We have no trouble. It does not float; it sinks, but not very quickly. In feeding meats you have all probably found that a chunk has settled to the bottom and the fish have difficulty in getting their jaws into it and pulling it to peices. This milk mixture, although it is heavy and somewhat sticky, comes to pieces quite readily, and invariably after it is bitten into it is left irregular in shape and the

next fish can get a good hold of it. I believe they pull to peices the chunks containing milk more quickly than they do the meat alone.

MR. LAIRD: Have you made any experiments with that liver compound after it has been processed?

MR. EBEN W. COBB: Meal?

MR. LAIRD: No, a medicinal product that they are making now—what is left, the residue, is just a finely ground powder. I wonder if you had had it.

MR. EBEN W. COBB: Dr. McCay, I believe, had some of that and has been analyzing it and figuring on it.

MR. TITCOMB: We are going to put in a basic experiment on that. The question is, how much of it is obtainable.

MR. CULLER: I may inform Mr. Laird that we tried out a small quantity of that hydrated liver, and the fish apparently did very well with it. We are going to try it out further this winter in the dry form, and then put boiling water over it and try it from every angle that we can.

MR. N. B. SCHOFIELD: On the Pacific coast great quantities of fish meal are being turned out, and it is real fish meal. California alone put out 17,000 tons of fish meal last year. Fish meal is being produced in British Columbia also.

MR. TITCOMB: A great deal of fish meal is being produced by the Atlantic Coast Fisheries Company, I think it is called, but they send most of their product to Germany. We tried a bag of that meal but it had so much bone in it—scrap pieces of bone—we could not use it.

MR. N. B. SCHOFIELD: The meal which is being produced on the Pacific coast is from the sardines, and there are no large bones in it.

MR. TITCOMB: It includes the entire fish, does it?

MR. N. B. SCHOFIELD: Yes.

MR. TITCOMB: Is it made from fish which are a little stale and unfit

MR. N. B. SCHOFIELD: No, it is made from the fresh fish. It is a valuable food for stock and is being used for that purpose. Germany has taken large quantities of it.

MR. TITCOMB: Do you know the price per pound?

MR. N. B. SCHOFIELD: About $60. per ton.

MR. TITCOMB: That is about the same as our fish meal on the east coast.

MR. N. B. SCHOFIELD: This is a better fish meal, I will tell you.

MR. GRAY: We are producing three or four different kinds of fish meal out here, in fact, several different grades of each kind, according to the process that happens to be used. We have quite a large tonnage of Alaska herring meal, as well as sardine and pilchard meal. The herring meal is made out of whole, fresh fish, the bones all ground up, the oil pressed out of it, and then dried. Most of them use the direct heat drying process, which in some cases scorches the meal, and that might make it objectionable as fish food, but I think it would be worth trying. Some of them use the steam process, by which scorching is avoided. I believe they get a high price for it for stock food. Recently a process has been developed of using salmon eggs that are discarded from the canneries for the preparation of special food. It is a subject in which I have never particularly interested myself, but I understand that the material is popular with the trout farms around the state, and I think it would be worth while for any members interested to make a little inquiry about this matter.

MR. TITCOMB: Salmon eggs are rather concentrated food. I believe you can feed for a certain length of time on salmon eggs alone but not continuously. It might be a very good food to mix with some of our other foods.

MR. KEIL: Would that not be almost entirely albumen?

MR. TITCOMB: That I do not know.

MR. KEIL: There would not be any protein in that, to speak of.

MR. TITCOMB: Well, they have fed fish on it for about three months, I know.

MR. FASTEN: This may not be a practical question, but have you ever tried brown locust, dried locust?

MR. TITCOMB: Has anybody here tried locust?

MR. KEIL: Yes, we tried them on one occasion in the east. We had some large cakes of pressed locust or grasshoppers from the Argentine shipped in, in a form somewhat similar to the cotton seed or cotton oil cakes. We had to abandon it entirely; the mortality increased to such an extent that we had to give it up.

MR. TITCOMB: That will end the nutrition discussion, unless you have further questions. I hope that you have brought out all the points of interest that each individual has come in contact with in his own experience, because the question is certainly a very important one at the present time. I imagine that with the increase in commercial hatcheries, the tendency to raise larger fish at the state and federal hatcheries, and the nurseries that are being encouraged by the Izaak Walton League, we will probably expend about double what was expended last year for this material.

# THE EFFECTS OF WASTE SULPHITE LIQUOR ON EARLY STAGES OF THE CHINOOK SALMON, AND MEANS OF PREVENTION BY DISPOSAL METHODS*

By H. W. Nightingale,
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and
V. Loosanoff,
*Biological Assist., Washington State Departments of Health and Fisheries.*

## INTRODUCTION

With an increasing number of sulphite pulp mills in operation in the State of Washington, it has become necessary to control the discharge of the wastes, in order to prevent deleterious effects upon fish life. In order to obtain fundamental facts upon which to base the disposal requirements for mills discharging sulphite liquor, experiments concerning the effects of sulphite liquor on certain stages of the chinook salmon were conducted during 1928 at the Auburn Hatchery by the Division of Sanitation of the State Department of Health in cooperation with the State Department of Fisheries.

## PREVIOUS INVESTIGATIONS

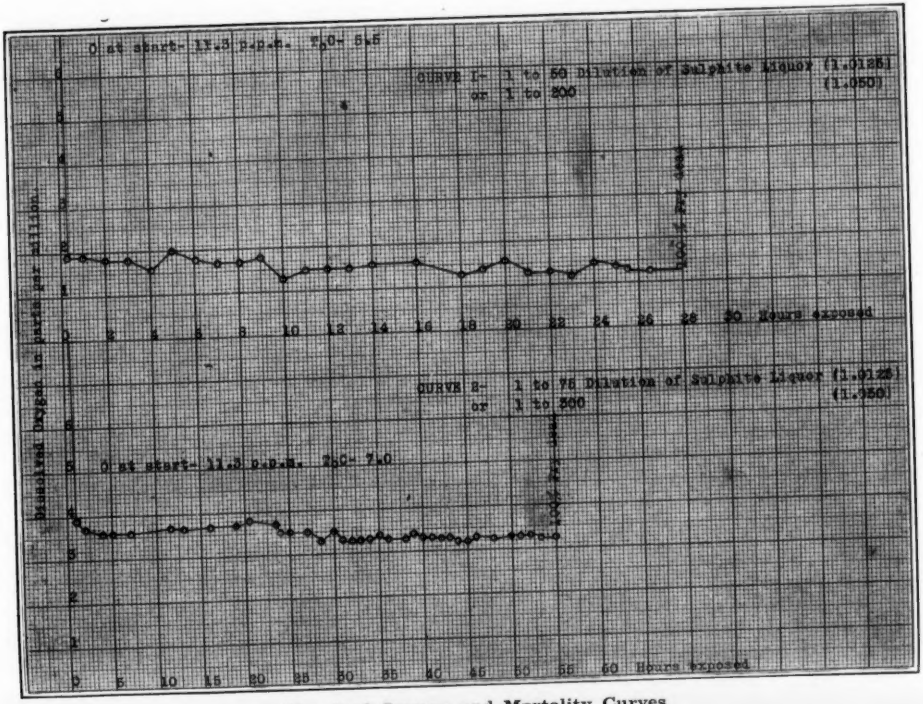
Marsh[1] found that sulphite liquor (density 1.028 at 11°C) in a dilution of 1 to 50, without aeration, killed 9 out of 12 brook trout fry in 48 hours; a 1 to 75 dilution killed 10 out of 12 in 113 hours. A 1 to 100 dilution without aeration killed perch in 52 hours, A 1 to 120 dilution without areation killed bass in 29 hours. With aeration a 1 to 100 dilution failed to kill bass in 17 days.

In Wisconsin[2] the death of fish in the Flambeau River during the summer of 1925 was stated to be caused by a lack of dissolved oxygen, resulting partly from the oxygen demand of the sulphite liquor discharged therein. The use of two parts per million of dissolved oxygen, corresponding to 14 to 22 per cent saturation, depending upon whether the temperature is 0° or 20°C respectively was considered the critical or very lowest limit for fish life. It was further concluded that the ponding and aeration of the diluted sulphite liquor reduced the oxygen demand 76 to 92 per cent for one-half to five day demands. Mechanical aeration by the Bassler spray

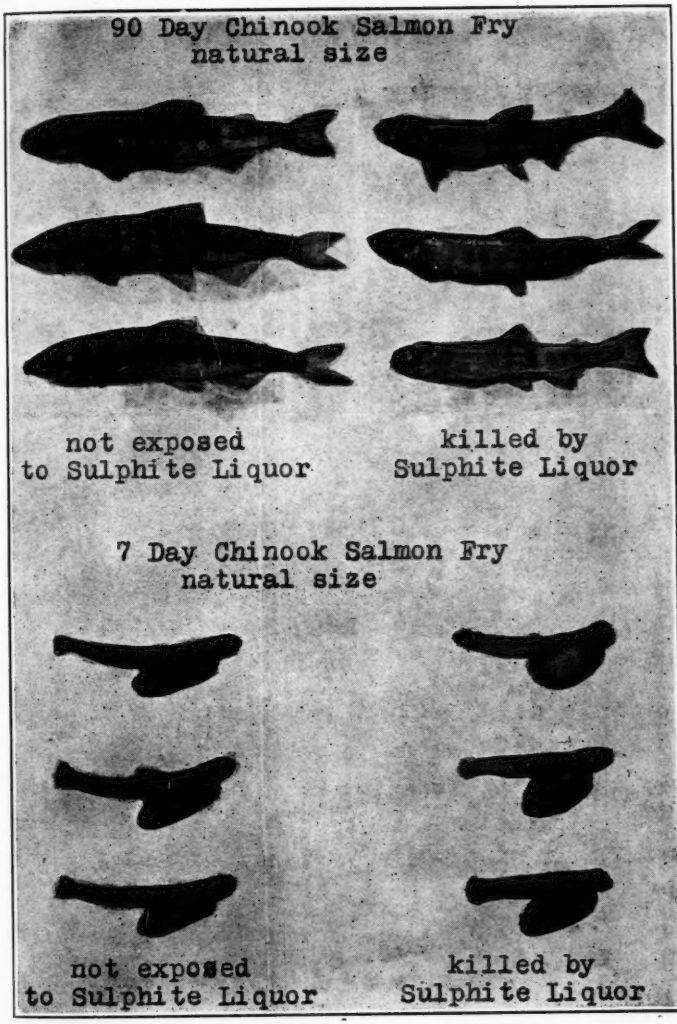
*Resume of original paper, which gave detailed observations and extensive data.

[1]Marsh. M. C., Water Supply Paper 192, U. S. Geological Survey, 1907.

[2]Wisconsin State Board of Health, Stream Pollution in Wisconsin by the Bureau of Sanitary Engineering, 1927.


O at start- 11.3 p.p.m. T°C- 5.5
CURVE 1- 1 to 50 Dilution of Sulphite Liquor (1.0125) (1.050)
or 1 to 200
100% dead
Dissolved Oxygen in parts per million.
Hours exposed
CURVE 2- 1 to 75 Dilution of Sulphite Liquor (1.0125) (1.050)
or 1 to 300
O at start- 11.3 p.p.m. T°C- 7.0
100% dead
Hours exposed

Dissolved Oxygen and Mortality Curves




Chinook Fry Unexposed and Exposed 1 to 37½ Dilution of Sulphite Liquor

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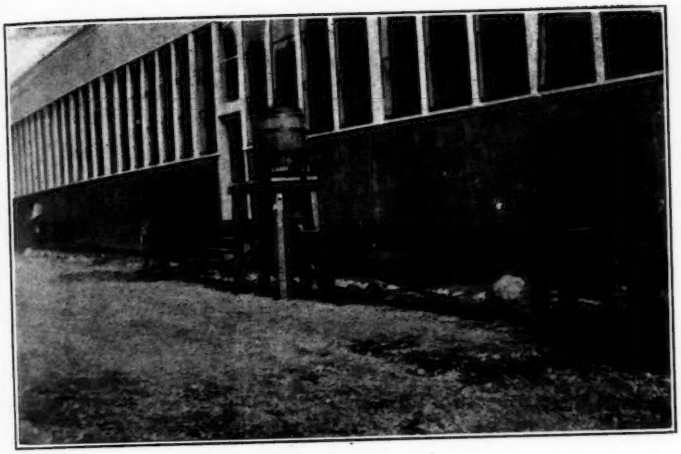
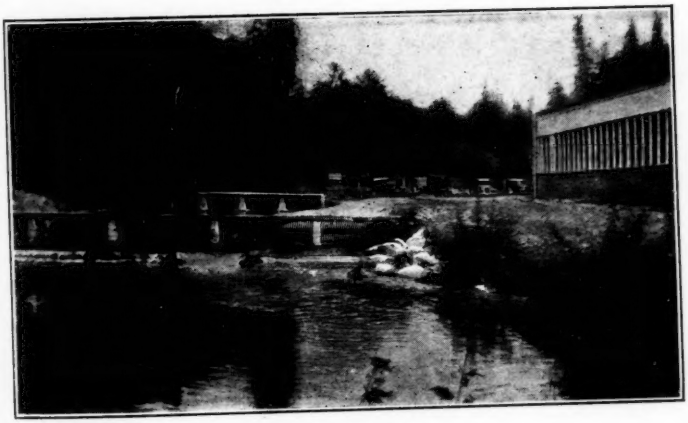


Control Apparatus



Soos Creek Hatchery

UNIV. OF MICH.

device reduced the oxygen demand of the diluted (1 to 32) liquor from 34 to 60 per cent for 1 to 5 day demands under experimental conditions.

## METHODS OF WORK

The species of salmon used in these experiments was *Oncorhynchus tschawytscha*, locally known as the Chinook, King, Quinnat, Tyee, Columbia River and Sacramento Salmon. The eyed eggs, fry and fingerlings were exposed to the sulphite liquor. The fry were 7, 10, 25, 100, 110 days old respectively. At the 110 day stage, the yolk sac was almost absorbed. The fingerlings were four and five and one-half months old.

The standard hatchery trough at Auburn, which is 14 feet in length, 14 inches wide, and 8 inches inside depth, and holds approximately 37.5 gallons of water, was used in these experiments. Hatchery water at the rate of two and one-half gallons per minute was admitted to the trough in a thin sheet about 4 inches wide. Sulphite liquor of certain densities was introduced in a small stream directly in the centre of the sheet of water in order to insure mixing and to avoid aeration, and because such a method of exposing the fish to the liquor would closely approximate conditions existing in sluggish streams or creeks.

A constant head device was arranged to introduce the liquor at constant rate through a glass spigot. The rates of flow of the liquor and trough water were frequently checked during the experiments and found to be under accurate control. The density of the sulphite liquor was determined by means of a hydrometer and more accurately by weighing in a pycnometer. Hydrogen-ion concentration was determined by means of the LaMotte standards.

Control troughs were also provided in which hatchery water was caused to flow continuously at the rate of two and one-half gallons per minute. 1000 fry of the 7 day stage and an equal number of the 90 day, were placed in the control troughs on January 31, 1928, at the start of the experiments. When fingerlings became available, 500 were also placed under control. The two and one-half gallon rate of water flow is much smaller than that used in actual hatchery operations where large numbers of fry are kept during development.

The following dilutions of sulphite liquor were used. Specific gravity 1.0125, 1:37.5, 1:50, 1:75, 1:80, 1:100, and specific gravity 1.00625, 1:75.

Aeration of the liquor before introduction into the dilution troughs was accomplished by means of a Lilly spray pump, which was equipped with an adjustable (pneumatic) nozzel. Aeration of the sulphite liquor (1.050 density) diluted 1 to 4, by means of the spray pump did not produce any reduction in the immediate demand for dissolved oxygen. The liquor of the above strength was selected for this test since it approached the dilution usually met with in sulphite mill discharge, that is, 1 part of liquor to 3 parts of wash water. The 1 to 4 liquor prepared from the undiluted sulphite liquor (1.050 density) was sprayed in a fine mist form and was also charged with air by pumping. In the latter test, air was pumped by hand through the spray pump into a 50 gallon barrel containing the 1 to 4 liquor for a period of one hour. Had the liquor been diluted 1 to 32 as in the Wisconsin experiments before aeration, undoubtedly a reduction in oxygen demand would have taken place. However, liquor of such strength again diluted to the proportions used in our experiments would not have shown deleterious effects on the fish.

## RESULTS

The results of the experiments are given in the following table. One thousand 7 day fry, 1000 90 day fry and 500 fingerlings were kept alive in the control troughs for periods of six to eight weeks. The fingerlings were fed canned salmon. The two and one-half gallon per minute water rate was used.

The 1.050 density sulphite liquor is the undiluted liquor before wash water has been applied during pulp washing in the mill. The reaction of the water was changed from pH 7.6 to 5.0 for a 1:37.5 dilution of sulphite liquor of 1.0125 density, to 5.4 for 1:50, to 5.8 for 1:75, to 6.2 for 1:80, and to 6.4 for 1:100; and to 6.6 for a 1:75 dilution of sulphite liquor of density 1.00625.

## CONCLUSIONS REGARDING TOXICITY OF SULPHITE LIQUOR

1. Sulphite liquor, density 1.0125, when diluted 1 to 37.5 proved to be fatal to Chinook fry after four and one-half hours. exposure. The minimum dissolved oxygen concentration during this exposure was zero parts per million. Chinook eggs when exposed to this dilution for 24 hours, show a 30 per cent mortality one month after transfer into the control trough, and 35 per cent mortality when exposed for 36 hours. In the control trough, eggs not exposed to the liquor, showed a mortality of only 1.3 per cent. The development of the eggs after 24

Table 4A

**Dilutions of Sulphite Liquor and Effects Upon Chinook Fry and Fingerlings**

| | | | | | | |
|---|---|---|---|---|---|---|
| Original Concentration of Liquor | 1.0125 | 1.0125 | 1.0125 | 1.0125 | 1.0125 | 1.00625 |
| Dilution | 1/37.5 | 1/50 | 1/75 | 1/80 | 1/100 | 1/75 |
| Equivalent to 1.050 Liquor in dilution of | 1/150 | 1/200 | 1/300 | 1/320 | 1/400 | 1/600 |
| Number of Fry | 500-7d<br>500-90d | 500-7d<br>500-90d | 500-7d<br>500-100d | 500-10d<br>500-110d | 500-25d<br>..... | .....<br>..... |
| Number of Fingerlings | ..... | ..... | ..... | ..... | 500-<br>4 mo. | 300-<br>5½ mo. |
| Per Cent Fry killed | 100 | 100 | 100 | 100 | 38.5 | ..... |
| Per cent Fingerlings killed | ..... | ..... | ..... | ..... | 25.5 | 1.33 |
| Time required to kill Fry | 4½ hrs. | 28 hrs. | 55 hrs. | 77 hrs. | 146½ hrs. | |
| Time required to kill Fingerlings | ..... | ..... | ..... | ..... | 146½ hrs. | 122½ |
| Min. Diss. $O_2$-p. p. m. | 0.0 | 1.2 | 3.2 | 4.0 | 4.9 | 6.4 |
| Max. Diss. $O_2$-p. p. m. | 1.6 | 2.0 | 3.8 | 4.2 | 5.4 | 6.6 |

**Death Rates in Control Troughs During Same Periods of Time**

| | | | | | | |
|---|---|---|---|---|---|---|
| Time | 4½ hrs. | 28 hrs. | 55 hrs. | 77 hrs. | 146½ hrs. | 122½ hrs. |
| Per cent 7 day Fry dead | 0.0 | .1 | .2 | .2 | .3 | ..... |
| Per cent 90 day Fry dead | 0.0 | .1 | .2 | .3 | .4 | ..... |
| Per cent Fingerlings dead | ..... | ..... | ..... | .3 | .3 | 1.33 |

to 36 hour exposure periods is retarded. Abnormalities in development occurred among the fry which hatched. Consequently a 1 to 37.5 dilution of sulphite liquor, density 1.0125, is dangerous to Chinook eggs.

2. Sulphite liquor, density 1.0125, diluted 1 to 50, proved to be fatal to Chinook fry after 28 hours exposure. No effects were produced on the fry after six hours. The minimum dissolved oxygen during the test was 1.3 parts per million.

3. Chinook fry, 90 day stage, when transferred into the control trough after 12, 18 and 24 hour periods of exposure to the 1 to 50 dilution of 1.0125 liquor, showed a mortality of 0, 15, and 32.5 per cent respectively, during a two weeks transfer period. The seven day fry, when transferred under the same conditions, completely recovered, with the exception of those exposed for 24 hours, which showed a 5 per cent mortality.

4. Sulphite liquor of 1.0125 density, diluted 1 to 75, proved fatal to Chinook fry in 55 hours.

5. The liquor of 1.00625 density, when diluted 1 to 75, produced no deleterious effects upon Chinook fingerlings during 122½ hours exposure. When transferred to a control trough for a four weeks period, no abnormal effects were observed. The size of the fingerlings was normal for their age.

6. Sulphite liquor, density 1.0125, diluted 1 to 80, proved fatal to Chinook fry in 77 hours.

7. From these experiments it is evident that Chinook salmon in early stages should not be exposed to water containing no dissolved oxygen for any period, however brief.

8. The period of time during which Chinook fry may be exposed to sulphite liquor without deleterious effects, depends upon the dilution.

(1) A safe exposure to a 1 to 37.5 dilution of sulphite liquor of 1.0125 density would be one hour, providing the original concentration of dissolved oxygen in the water before introducing the liquor is sufficient to allow a balance of 1.6 p. p. m. during the exposure.

(2) A safe exposure to a 1 to 75 dilution of sulphite liquor of 1.0125 density would be 18 hours, providing the original content of dissolved oxygen is sufficient to allow a balance of 3.5 p. p. m.

(4) A safe exposure for fingerlings to a 1 to 75 dilution of sulphite liquor of 1.00625 density would be at least 122½ hours, providing that the balance of dissolved oxygen is 6.5 parts per million.

(5) A safe exposure for eyed Chinook eggs to a 1 to 37.5 dilution of 1.0125 density of the liquor, would not be more than 6 hours, providing the original dissolved oxygen content is such as to allow a balance of at least 1.0 p. p. m.

9. Aeration of the 1 to 4 liquor, (density 1.0125), by means of Lilly pump and spraying device, before introducing the liquor into the trough of following water, failed to lessen the instant or immediate demand for dissolved oxygen. Consequently the effects upon the fry were the same for a given dilution and strength.

10. In the lesser dilutions the sulphite liquor appears to have a chemical effect upon the scales of the Chinook fry, since the Parr marks disappear. The acidity in the lesser dilutions also has undoubtedly an effect on the fry. Fish are known to thrive poorly in acid waters.

## DISPOSAL METHODS

The problem of the disposal of waste sulphite liquor has occupied the attention of chemists for a considerable number of years. Attempts have been made to concentrate the diluted liquor by evaporation for the preparation of road, core, and coal briquette binders. The market for such products in the west is small. The liquor, after concentration can be used as a fuel for boilers. Evaporation costs have thus far prevented the economic use of the concentrate for such purposes.

Since the effect of sulphite liquor in fresh or in salt water is that of dissolved oxygen reduction, aeration has been proposed as a means of counteracting the oxygen demand. In the Wisconsin studies a combination of ponding and aeration was found to be of value in a location where the physical conditions along the river were favorable. Where the mill location adapts itself to ponding, it is undoubtedly a valuable procedure since a partial reduction of oxygen demand takes place in the pond and to a slight extent during cascading the impounded liquor in a thin sheet into the stream.

Mechanical aeration by means of spray devices on an experimental scale has been shown by the Wisconsin studies to be effective in reducing the 1 to 5 day oxygen demand, with liquor diluted 1 to 32 with wash water. For large mills of 100 tons and up, the cost of installing and operating an aeration plant equipped with fine sprays would be high since a large volume of liquid would have to be handled.

Since sulphite mills under the Washington law must avoid the pollution of strictly fresh waters, owing to the fact that such waters are or may be used for drinking purposes, our problems with this waste concern mill locations near the mouths of rivers or on salt water.

For these reasons it has been found practicable to store the diluted sulphite liquor in large wooden tanks and to discharge rapidly during the first of the ebb tide into an adequate volume of water. In some instances the liquor is diluted 1 to 8 before discharge, instead of the usual 1 to 4. This procedure is necessary in cases where the water available for immediate dilution in the water course is insufficient to protect conditions near the outlet. Since the mouths of the rivers are under tidal influence, the volume of water available for dilution during and after discharge is greatly increased by the influx of the sea water.

The Shelton, Washington, Pulp Mill disposal system[3] has proved to be satisfactory from the standpoint of preventing the reduction of dissolved oxygen in the salt waters adjacent to the outlet. During the discharge of liquor (1 to 4) from these tanks at high tide, reductions of only one to two parts per million of dissolved oxygen have occurred in the sea water between 100 to 150 feet from the outlet.

No special disposal methods for the sulphite liquor have been found to be necessary for mills located near large bodies of salt water. It is of economic interest to mill owners to locate their mills in such places.

### *Discussion*

PRESIDENT MOORE: Now is an opportunity to put a practical question to the scientist, or, if you like, a scientific question to the scientist.

MR. GRAY: When this liquor is diluted, does it have a tendency later to settle out in the low river areas?

MR. NIGHTINGALE: No, it is soluble in water in all proportions. It is a peculiar compound, a colloid; which is difficult to precipitate from the water. A mill owner told me that when electrodes are placed in sulphite liquor a precipitate has a tendency to form. That method, however, has never been successful on a commercial scale. It is possible that the use of ozone may prove successful.

MR. VIOSCA: Have you tried to precipitate your chemical with alum?

[3]Stream Pollution Problems in the State of Washington and their Solution. The American Fisheries Society.

MR. NIGHTINGALE: We have tried alum precipitation but we have had no success with it. It is colloid that is not easily broken up.

MR. VIOSCA: What is the difference between the sulphate and the sulphite mills in this respect?

MR. NIGHTINGALE: I have not devoted any time to the study of the sulphate mills but expect to do so.

MR. WILLIAMS: Is the effect on fish the same from a sulphate mill as from a sulphite mill?

MR. NIGHTINGALE: The relation has been worked out to a certain extent by the Wisconsin Board of Health and the Conservation Commission. The taking up of oxygen in the sulphate process is far less than in the sulphite process. In other words, the oxygen consuming effect of a sulphate mill is about that of an equal quantity of sewage. However, the sulphate mill presents its own problems; since the mercaptan and methyl sulphides may possibly drive the fish away from certain streams.

MR. N. B. SCHOFIELD: I would like to ask if experiments have been tried on the effect of either sulphite or sulphate on the spawning fish or on the eggs in the gravel in the stream.

MR. NIGHTINGALE: Not in the streams. In our paper we have merely taken eggs which were stripped from fish, placed them in the trough, and observed the effect after a certain period. For example, we put the Chinook eyed-eggs in troughs and exposed them to the 1 to 37.5 dilution of liquor for periods of 24 and 36 hours respectively, then took them out and placed them in perfectly clean water. During a period of one month in these control troughs we had a mortality of 30 to 35 per cent. The eggs became covered with a scarcely visible slime, and in many cases the embryo stopped wriggling. Also some peculiar monstrosities occurred among the few embryos which developed after the period of contact with the liquor in the control trough.

MR. N. B. SCHOFIELD: Some experiments in this line were tried about fifteen years ago in California, on the Truckee river, in connection with the Floriston paper mill.

MR. NIGHTINGALE: I have looked up the literature, but I haven't seen any publication on that work.

MR. N. B. SCHOFIELD: It was not published, but I happened to be one of those who helped in the experiment. What we attempted to determine was the effect of the operations of the mill on the fish in the stream. Below the mill the trout fishing is considered as good as any-

where in the river. The mill had no appreciable effect upon salmon fingerlings which were below the mill for three or four weeks. Salmon eggs were buried in the gravel above the mill and below the mill. In every instance the salmon eggs were killed quickly below the mill, while all those above the mill were unaffected.

MR. NIGHTINGALE: Do you say the fingerlings were not affected by the waste?

MR. N. B. SCHOFIELD: They were not affected.

MR. NIGHTINGALE: Where were they located?

MR. N. B. SCHOFIELD: About a mile below the mill.

MR. NIGHTINGALE: Not knowing the dilutions in the river or the volume of liquid discharged, it would be hard to arrive at a conclusion in that respect. If the wastes were concentrated as a result of the flood tide holding the water in and preventing the waste liquor from going out to sea, these high concentrates would surely have an adverse effect.

MR. N. B. SCHOFIELD: Our experience might be of value, in that the sulphite or sulphate, whichever it was, was very much diluted and had no effect on the fry or fingerling. But it does have an effect on the eggs when they are buried in the gravel. I came to the conclusion that the lack of oxygen is greater in the gravel in the bottom of the stream than it is in the water. It is a very turbulent stream, and evidently it becomes aerated on its way down.

MR. NIGHTINGALE: Were there fibres in the waste?

MR. N. B. SCHOFIELD: Yes.

MR. NIGHTINGALE: They might form a mat which would further decrease the availability of oxygen. We screened the liquor before we ran it into these troughs in order to keep fibres out. The fibres are the subject of another experiment. But these tidal area problems are different. In our experiments we find that the fingerlings are affected by certain concentrations. While we do not know what your concentrations are, there is no doubt that the fingerlings were affected in our experiments.

MR. N. B. SCHOFIELD: If it had no effect on the fish it might destroy the stream as a spawning stream?

MR. NIGHTINGALE: Yes.

MR. N. B. SCHOFIELD: As a result of some English work it has been suggested that the presence of sulphite in the water, even in very dilute quantities, would practically kill the spermatozoa and prevent the spawning of the fish.

DR. WARD: I think this is one of the most important investigations which could possibly be conducted. I have listened with the greatest interest to the paper, and have been especially struck by the suggestions regarding the tests that have been made. I am confident that this installation is much better than that ordinarily used and the method ordinarily employed. The chemical problems involved are extrordinarily complex. I should hesitate myself to enter into a discussion of them, as I am not a chemist. Consequently I must confine myself to things which are biological in character, prefacing my remarks by a restatement of the fact that a thorough investigation of this character deserves the most cordial approval of this organization.

I am not sure I understood your statement about that experiment in the last column of the table which has been distributed, where it indicates that 1.33 per cent of the fingerlings were killed, but where you did not consider that result significant.

MR. NIGHTINGALE: The fact that an equal number of fingerlings died in the control trough during the experiment has led us to believe that no deleterious effects were produced upon the fingerlings in the dilution trough. The fish that died in the dilution trough showed no evidence of slime.

DR. WARD: Superficially it would indicate that the controls were not well managed. If you have that death rate there you are not justified, in my opinion, in suggesting that those which died in this experiment were not destroyed by the effect of the liquor.

MR. NIGHTINGALE: Slime appears to be one of the first evidences of the fish being effected. In following the various control experiments we found that slime did not appear on the fish. Our death rate in the control troughs ranged at various periods from one-tenth up to four-tenths per cent, and in this particular instance the figure given. In an experiment of this kind the controls must be very carefully handled.

DR. WARD: The general effect of a colloid is to produce a precipitation or the formation of a different colloid on the surface of the fish. That has been beautifully shown by the experiments of Dr. Kathleen Carpenter in Wales on the effects of lead wastes in streams, where an almost imperceptible amount of pollution results in the formation of a colloid. I mention it here because once this slime has begun to form the outcome is apparently inevitable, and I am not sure that you have elimi-

nated the possibility of that here. It may be that 146 hours, which seems to be the maximum period, is not sufficient to point out what would be the ultimate results, because some of these processes, especially those that are followed by the formation of a film on the surface, will lead inevitably to fatal results, since the formation of that film on certain parts of the surface, as on the gills, where it might also be found, results in the gradual stopping of the respiratory function and so death of the organism, even though its powers of resistance may carry it along for a considerable period of time.

MR. NIGHTINGALE: In these tests we designate as a safe concentration the dilution which fish can survive in a definite time limit, 122½ hours subject to a four weeks check in a control trough. I do not say that the 1 to 600 dilution on the 1.05 basis is a safe dilution for more than 122½ hours. The problems of mill locations in this State are such that it is not necessary to consider the effects over a greater period than what we have used in our experiments. The experiments have regard to location of the mills and the length of time the fish would probably be exposed to such concentrations of liquor. The range at our mills will not admit of over 6 hours under any conditions. Undoubtedly if a research department of a university had the time to carry this matter on for a considerable period they would probably find other interesting facts.

DR. WARD: In order to represent adequately the interests of the public your experiments ought to be carried to the point where those interests would be absolutely protected, do you not think so?

MR. NIGHTINGALE: Owing to the fact that these mills are erected in places where the length of time will never approximate those periods, this point appears to be of a more theoretical than practical interest.

DR. WARD: I am undoubtedly radical, and I am perfectly willing to confess that in this discussion and before this organization. In general the interests of the manufacturer are adequently protected because he secures the best expert advice that he can get, and the explanation given is often sufficient to create a prejudice in the mind of the reader in his favor. Those who support the public interest must with equal vigor point out all the possibilities of trouble in connection with subjects that are not thoroughly investigated. We run up constantly against complications which have not been considered in the argument and which introduce very serious difficulties into the situation.

Now, I feel it incumbent on me—expressing merely my individual c[illegible]on—to call attention, in a fashion that I hope Mr. Nightingale will

consider thoroughly courteous and not in any way critical, to another comment of his. In my opinion these experiments are exceedingly important and very valuable; at the same time—if I am wrong Mr. Nightingale will correct me—I caught the expression that he had not gone further with a consideration of the Wisconsin experiments because the cost would be large. Now, that is the crux of the whole situation. Various pollutors have been urging for many years, since the campaign against pollution started, that it was throwing the expense upon the manufacturer. I want to call your attention clearly to the fact that no manufacturing interest is of public benefit when the cost to the public is greater than the profit to the manufacturer. There is no possibility of saying that the public is benefited by a manufacturing interest that returns to the public $50,000 a year in one form or another when the destruction of the natural resources totals $100,000 a year. It is simply taking $1 out of one pocket and putting fifty cents into another, and the public interest is not served thereby. This goes a great deal further, Mr. Nightingale, than your paper; it touches definitely the entire subject of pollution. The State of Wisconsin has spent an enormous amount on the study of sulphite liquors. Results have been secured there which have not been attained at any other place, and in my opinion these results must be considered, regardless of their apparent cost, and their adaption to industry in every part of the country must be calculated most carefully. We shall never get anywhere if we permit any manufacturer or any industry to say that it is going to cost too much to correct the difficulty and prevent the destruction which arises by virtue of the processes they are carrying out. To use a common illustration which will be perfectly evident to all of you, this is a great dairy region. You provide by state law for the control of those dairies. The dairy does not produce merely one product; it yields two chief products, milk and manure. You demand that those two products be kept absolutely separate and that the second I have mentioned be so handled that it shall not jeopardize the public welfare in any fashion whatever. It is not unreasonable, then, to require of manufacturers in other lines of buisness that they handle properly all the products of their industry. That is not a new doctrine; it is enforced in England, Belgium, France, Germany; and the paper mills—to come back to this particular item—in those countries care for their wastes in a way that no paper mills in this country have ever cared for them.

I happened to be actively concerned in the discussion with the paper mills on the Hudson River in New York State in 1918, when I was asked by the Conservation Commission to look into the situation there and make a report to them. The statement I have just made to you regarding paper mills of this country was made to a group of paper mill men, and they were unable to contradict it. The Hudson has been substantially destroyed as a productive stream; it no longer has the

value to the public that it originally had in the matter of the production of fish, a natural resource of immense value. That resource, with all the recreation that also involved, has been destroyed primarily by the paper mills of various kinds. That does not, of course, affect the immediate situation here, for many of these are of a different type. Many of them have not, or had not at that time, introduced the various types of apparatus to which Mr. Nightingale has referred. But I make this statement to bring before the people in this organization perfectly clearly and distinctly the issue at stake. It is a question whether the public interest, which is unrepresented unless it be by workers in technical societies such as this, is being adequately protected. Are we going to argue that because methods are expensive, they should not be considered? The real question is what is the balance. If the public gains more by the destruction of any resource, the public then can choose the extent to which it is willing to be penalized by the introduction of a certain method and a certain manufacturing interest. But if the public loses, society certainly does not gain at any point.

I hope Mr. Nightingale will excuse me for having departed from the discussion of this particular paper, because I am so radical that I feel it is essential on occasions to emphasize this phase of the subject. The splendid work you are doing will lead ultimately to the following out of this matter to its fullest extent so that the public interest will be protected at every point, and I want to see you carry on these experiments and not stop them short of that.

MR. NIGHTINGALE: The suggestions are taken very kindly, Dr. Ward. I have not the least doubt that the aspect of the work to which you refer should be taken into consideration.

THE PRESIDENT: If there is no further question, I am sure, Mr. Nightingale, I can speak for the members in extending our thanks for this remarkably fine, clear and practical demonstration.

# BANQUET

**At the International Wild Life dinner given in the Venetian Gardens of the Olympic Hotel, on Wednesday evening, August 29th, a roll call was taken of the nations represented, as follows:**

| | |
|---|---|
| **Argentine Republic** | **Japan** |
| **Belgium** | **Mexico** |
| **Bolivia** | **Netherlands** |
| **Chile** | **Nicaragua** |
| **Costa Rica** | **Norway** |
| **Czechoslovakia** | **Peru** |
| **Ecuador** | **Russia** |
| **France** | **Sweden** |
| **Germany** | **Spain** |
| **Greece** | **Switzerland** |
| **Italy** | |

## BANQUET SPEECH

By Dr. Emmeline Moore

*President of the American Fisheries Society.*

Mr. Toastmaster, what I can say in the brief time alloted to the speakers on this occassion might be called "a shallow dip into the history of fish culture." Conveniently we may divide it into three periods: first, the experimental age,—it may also be called the age of sensation, and even the age of migration: second, the age of piscatorial combats—an age which represents the mingling of the practical and the scientific; and third, the age in which we now are, the age of thrills, the age with a kick in it.

In the first period the outstanding event, epochal in significance, occurred in the late fifties in an improvised hatchery in Ohio (some claim the event took place in Canada just previous to this date). It was the discovery that the eggs of the Salmonidae could be artificially impregnated, hatched into vigorous fry and reared to adulthood. Fishculturists were wildly enthusiastic, and there began for the Salmonidae an era of migration. Atlantic salmon went into the Pacific ocean; Pacific salmon, into the Atlantic; shad, into Great Salt lake; trout into the Mississippi. And so the merry-go-round of fishes went on. About that time a notorious alien entered this country through Castle Garden—the beautiful, wily but not toothsome carp. It was received officially at Washington, next taken to the hearts of the Congressmen, who according to the best tradition of the garden seeds, dispensed them unwittingly into our game fish waters. Many errors were made by the enthusiasts of the time but we can see their mistakes quite justly for we are making some today.

In this period came the organization of the American Fisheries Society, perhaps in answer to prayer of how to deal intelligently with the fish question.

The next period is one in which the practical and scientific aspects of fish culture merge. It is the age in which the unpopular science becomes popular. The practical man vied with the scientific man. Many verbal combats were held over fry versus fingerling; beef hearts versus liver; closed season versus open season, all amicably settled on the common ground of fishing ground.

There arose in the midst of these difficulties between the practical man and the scientist a famous liaison officer.

Covering a period of about thirty years you may read of him in the Transactions of the American Fisheries Society. I cite him for distinguished service in bringing the practical man into amicable relationship with the scientific man—Mr. John W. Titcomb. (Applause)

During this period there arose in the various hatcheries great mortality of fish on account of fish diseases. Very soon Dr. Henry B. Ward, a pioneer in this field, put the matter beyond the "doctor book" stage. By his studies of the life history stages of the fish worm to its adult stage in the fish-eating bird, he put the reverse English on an old maxim—"It is the worm that catches the bird."

The next and last period, the one in which we find ourselves at present, is a period of thrills. Two years ago it was announced in medical circles that liver was useful in treating people afflicted with anaemia. That fact came like a thunderbolt into the ranks of the fishculturists. The lowly liver rose to place of astonishing importance economically. Its cost has trebled and it is climbing onward.

There are other thrills! In the state of Washington, so it is understood, where great hydro-electric developments necessitate it, escalators are being utilized to lift tired fish over the high dams. The broadening of fish culture into aquiculture provides another thrill in that "mother organisms" are the starter for the production of hosts of minute crustacea useful as food of young fish in ponds. And finally perhaps the greatest thrill of all lies in the plans of Commissioner O'Malley who by organizing a more effective trained personnel is making of the outdoor aquatic situation a super-university. (Applause)

# APPENDIX

# American Fisheries Society

Organized 1870

## Certificate of Incorporation

We, the undersigned, persons of full age and citizenship of the United States, and a majority being citizens of the District of Columbia, pursuant to and in conformity with sections 599 to 603, inclusive, of the Code of Law for the District of Columbia, enacted March 3, 1901, as amended by the acts approved January 31 and June 30, 1902, hereby associate ourselves together as a society or body corporate and certify in writing:

1. That the name of the Society is the American Fisheries Society.

2. That the term for which it is organized is nine hundred and ninety-nine years.

3. That its particular business and objects are to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; to unite and encourage all interests of fish culture and the fisheries; and to treat all questions of a scientific and economic character regarding fish; with power:

(a) To acquire, hold and convey real estate and other property, and to establish general and special funds.

(b) To hold meetings.

(c) To publish and distribute documents.

(d) To conduct lectures.

(e) To conduct, endow, or assist investigation in any department of fishery and fish-culture science.

(f) To acquire and maintain a library.

(g) And, in general, to transact any business pertinent to a learned society.

4. That the affairs, funds and property of the corporation shall be in general charge of a council, consisting of the officers and the executive committee, the number of whose members for the first year shall be seventeen, all of whom shall be chosen from among the members of the Society.

Witness our hands and seals this 16th day of December, 1910.

| | |
|---|---|
| Seymour Bower | (Seal) |
| Theodore Gill | (Seal) |
| William E. Meehan | (Seal) |
| Theodore S. Palmer | (Seal) |
| Bertrand H. Roberts | (Seal) |
| Hugh M. Smith | (Seal) |
| Richard Sylvester | (Seal) |

Recorded April 16, 1911.

# CONSTITUTION AND BY-LAWS.

(As amended to date)

## ARTICLE I

### NAME AND OBJECT

The name of this Society shall be American Fisheries Society. Its object shall be to promote the cause of fish culture; to gather and diffuse information bearing upon its practical success, and upon all matters relating to the fisheries; the uniting and encouraging of all interests of fish culture and the fisheries, and the treatment of all questions regarding fish, of a scientific and economic character.

## ARTICLE II

### MEMBERSHIP

*Active Members.*—Any person may upon a two-thirds vote of the members present at any regular annual meeting and upon the payment of one year's dues become an active member of this Society.

The annual dues of active members shall be three ($3.00) dollars per year, payable in advance. In case of non-payment of dues for two consecutive years, notice shall be given by the Treasurer in writing, and such member remaining delinquent after one month from the date of such notice, his name shall be dropped from the roll of the Society. Such delinquent member, having been dropped for non-payment of dues shall be ineligible for election as a new member for a period of two years, except upon payment of arrears.

*Club Members.*—Any sporting or fishing club or society, or any firm or corporation, upon a two-thirds vote of the members present at any regular annual meeting and upon the payment of one year's dues, may become a club member of this Society. The annual dues of club members shall be five ($5.00) dollars per year.

*Libraries.*—Libraries shall be admitted to membership upon application and the payment of one year's dues. The annual dues for libraries shall be three ($3.00) per year.

*State Memberships.*—Any State, Provincial of Federal Department of the United States, Canada or Mexico may, upon application and the pay-

ment of one year's dues become a state member of this Society. The Annual dues for State Memberships shall be ten ($10.00) dollars per year.

*Life Memberships.*—Any person may, upon a two-thirds vote of the members present at any regular annual meeting and the payment of fifty ($50.00) dollars become a life member of this Society and shall thereafter be exempt from payment of annual dues. The Secretary and Treasurer of the Society are hereby authorized to transfer members from the active list to the list of life members provided that no member shall be so transferred unless he shall make request for such transfer and shall have paid dues as an active member of the Society for at least twenty-five years.

*Patrons.*—Any person, society, club, firm or corporation, on approval of the Executive Committee and the payment of fifty ($50.00) dollars or more, may become a patron of this Society with all the privileges of a life member, and shall be listed in all the published membership lists of the Society.

*Honorary and Corresponding Members.*—Any person may be made an honorary or corresponding member upon a two-thirds vote of the members present at any regular annual meeting of the Society. The President (by name) of the United States, the Governors (by name) of the several states and the Secretary of Commerce of the United States (by name) shall be honorary members of the Society.

*Election of Members Between Annual Meetings.*—The President, Secretary and Treasurer of the Society are hereby authorized during the time intervening between annual meetings, to receive and act upon all applications for individual and club memberships. A majority of such committee shall decide upon the acceptance of such applications.

*Voting.*—Active members and life members only shall have the right to vote at regular or special meetings of the Society. Fifteen voting members shall constitute a quorum for the transaction of business.

## ARTICLE III

### FUNDS

*Current Fund.*—All moneys received from the payment of dues of active members, club members, libraries, life members, state members, sale of Transactions, contributions thereto, and from any miscellaneous sources, shall be credited to the Current Fund of the Society and shall be paid out only on vouchers regularly approved by the President and Secretary.

*Permanent Fund.*—The President, Secretary and Treasurer shall be the Trustees of the Permanent Fund. All moneys received from patrons, bequests and contributions thereto shall be credited to the Permanent Fund of the Society. Such fund shall be invested by the Treasurer in such manner as may be approved by the trustees of such fund. The members of the Society shall, at each annual meeting, determine the disposition of interest accruing from such investment.

## ARTICLE IV

### Officers

The officers of this Society shall be a President and a Vice-president, who shall be ineligible for election to the same office until a year after the expiration of their term; a Secretary, a Treasurer, a Librarian, and an Executive Committee of seven, which, with the officers before named, shall form a council and transact such business as may be necessary when the Society is not in session—four to constitute a quorum.

In addition to the officers above named there shall be elected annually five Vice-presidents who shall be in charge of the following five divisions or sections:

1. Fish Culture.
2. Commercial Fishing.
3. Aquatic Biology and Physics.
4. Angling.
5. Protection and Legislation.

No officer of this Society shall receive any salary or compensation for his services and no allowances shall be made for clerical services except by vote of the Society at regular annual meetings.

*Duties of Officers.*—The President shall preside at the annual and all special meetings of the Society, shall be ex-officio chairman of the Council of the Society, and shall exercise general supervision over the affairs of the Society.

The Vice-President shall act in the place of the President in case of absence or inability of the latter to serve.

The Secretary shall keep the records of the Society, attend to the publication and distribution of its Transactions, attend to its correspondence, promote its membership, and arrange for annual and special meetings.

The Treasurer shall receive and collect all dues and other income of the Society, shall have the custody of its funds and pay all claims which have been duly approved. The Treasurer shall furnish a bond in the sum of one thousand ($1,000.00) dollars to be approved by the Executive Committee and to be paid for by the Society.

The Librarian shall have the custody of the library of the Society, in-

cluding its permanent records and printed Transactions and shall have charge of the sale of surplus copies of such Transactions. Other officers shall perform such duties as shall be assigned them by the President.

## ARTICLE V

### Meetings

The regular meeting of the Society shall be held once a year, the time and place being decided upon at the previous meeting, or, in default of such action, by the Executive Committee.

## ARTICLE VI

### Order of Business

1. Call to order by the President.
2. Roll call of members.
3. Applications for memberships.
4. Reports of officers.
   a. President.
   b. Secretary.
   c. Treasurer.
   d. Vice-Presidents of Divisions.
   e. Standing Committees.
5. Committees appointed by the President.
   a. Committee of five on nomination of officers for ensuing year.
   b. Committee of three on time and place of next meeting.
   c. Auditing committee of three.
   d. Committee of three on program.
   e. Committee of three on publication.
   f. Committee of three on publicity.
6. Reading of papers and discussions of same.
   (*Note*—In the reading of papers preference shall be given to the members present).
7. Miscellaneous business.
8. Adjournment.

## ARTICLE VII

### Changing the Constitution

The Constitution of the Society may be amended, altered or repealed by a two-thirds vote of the members present at any regular meeting, provided at least fifteen members are present at said regular meeting.

# American Fisheries Society

## LIST OF MEMBERS, 1928-1929

## (Showing Year of Election to Membership)

### HONORARY MEMBERS

The President of the United States
The Secretary of Commerce of the United States.
The Governors of the several States.
'08 Antipa, Prof. Gregoire, Inspector-General of Fisheries, Bucharest, Roumania.
'06 Besana, Giuseppe, Lombardy Fisheries Society, Via Rugabello 19, Milan, Italy.
'09 Blue Ridge Rod and Gun Club, Harper's Ferry, W. Va.
'93 Borodin, Nicolas American Museum of Natural History, New York, N. Y.
'12 Calderwood, W. L., Inspector of Salmon Fisheries for Scotland, Edinburgh, Scotland.
'04 Denbigh, Lord, London, England.
'04 Kishinouye, Dr. K., Imperial University, Tokyo, Japan.
'88 Lake St. Clair Shooting and Fishing Club, Detroit, Mich.
'17 Mercier, Honoré, Minister of Colonization, Mines and Fisheries, Quebec, Canada.
'09 Nagel, Hon. Chas., St. Louis, Mo.
'95 New York Association for the Protection of Fish and Game, New York City.
'08 Nordqvist, Dr. Oscar Fritjof, Superintendent of Fisheries, Lund, Sweden.
06 Perrier, Prof. Edmond, Director Museum of Natural History, Paris, France.
92 Vinciguerra, Prof. Dr. Decio, Director Royal Fish Culture Station, Rome, Italy.

### CORRESPONDING MEMBERS

'84 Apostolides, Prof. Nicoly Chr., Athens, Greece.
'87 Armistead, J. J., Dumfries, Scotland.
'04 Ayson, L. F., Commissioner of Fisheries, Wellington, New Zealand.
'22 Director, All-Russian Agricultural Museum, Fontanka 10, Leningrad, Russia.
'22 Director of Fisheries (British Malay), Singapore, Straits Settlements.
'08 Higginson, Eduardo, Consul for Peru, New York City.
'84 Landmark, A., Inspector of Norwegian Fresh Water Fisheries, Christiania, Norway.

'22 Library, National Museum of Natural History, Paris, France.
'84 Marston, R. B., Editor of the Fishing Gazette, London, England.
08 Potteau, Charnley, Lommel, Belgium.
'84 Sars, Prof. G. O., Christiania, Norway.
'10 Stead, David G., Fisheries Department, Sydney, New South Wales, Australia.

## PATRONS

'14 Alaska Packers Association, San Francisco, Calif.
'15 Allen, Henry F., (Agent, Crown Mills), 210 California St., San Francisco, Calif.
'15 American Biscuit Co., 815 Battery St., San Francisco, Calif.
'15 American Can Co., Mills Building, San Francisco, Calif.
'15 Armour & Co., Battery and Union Sts., San Francisco, Calif.
'15 Armsby, J. K., Company, San Francisco, Calif.
'15 Atlas Gas Engine Co., Inc., Foot of 22nd Avenue, Oakland, Calif.
'15 Balfour, Guthrie & Co., 350 California St., San Francisco, Calif.
'15 Bank of California, N. A., California and Sansome Sts., San Francisco, Calif.
15 Bloedel-Donovan Lumber Mills, Bellingham, Wash.
'15 Bond and Goodwin, 485 California St., San Francisco, Calif.
'15 Burpee and Letson, Ltd., South Bellingham, Wash.
'15 California Barrel Co., 22d and Illinois Sts., San Francisco, Calif.
'15 California Door Co., 43 Main St., San Francisco, Calif.
'15 California Stevedore and Ballast Co., Inc., 210 California St., San Francisco, Calif.
'15 California Wire Cloth Company, San Francisco, Calif.
'15 Caswell, Geo. W., Co., Inc., 503-4 Folsom St., San Francisco, Calif.
'15 Clinch, C. G., & Co., Inc., 144 Davis St., San Francisco, Calif.
15 Coffin-Redington Co., 35-45 Second St., San Francisco, Calif.
'15 Columbia River Packers Association, Astoria, Ore.
'15 Crane Co. (C. W. Weld, Mgr.) 301 Brannon St., San Francisco, Calif.
'15 Dodge, Sweeney & Co., 36-48 Spear St., San Francisco, Calif.
'15 First National Bank of Bellingham, Bellingham, Wash.
'15 Fuller, W. P., & Co., 301 Mission St., San Francisco, Calif.
'15 Grays Harbor Commercial Co., Foot of 3d St., San Francisco, Calif.
'15 Hendry, C. J., Co., 46 Clay St., San Francisco, Calif.
'15 Jones-Thierbach Co., The, Battery and Merchant Sts., San Francisco, Calif.
'15 Knapp, The Fred H., Co., Arcade-Maryland Casualty Building, Baltimore, Md.
'15 Linen Thread Co., The, (W. A. Barbour, Mgr.), 443 Mission St., San Francisco, Calif.
'15 Mattlage, Chas. F., Company, 335 Greenwich St,. New York City.

'15 Nauman, C., & Co., 501-3 Sansome St., San Francisco, Calif.
'15 Oliver Salt Co., Mt. Eden, Calif.
'15 Morrison Mill Co., Inc., Bellingham, Wash.
'15 Morse Hardware Co., Inc., 1025 Elk St., Bellingham, Wash.
'15 Pacific Hardware and Steel Co., 7th and Townsend Sts., San Francisco, Calif.
'15 Pacific States Electric Co., 575 Mission St., San Francisco, Calif.
'15 Phillips Sheet and Tin Plate Co., Weirton, W. Va.
'15 Pope and Talbot, Foot of 3d St., San Francisco, Calif.
'15 Puget Sound Navigation Co., Seattle, Wash.
'15 Ray, W. S., Mfg. Co., Inc., 216 Market St., San Francisco, Calif.
'15 Schmidt Lithograph Co., 2d and Bryant Sts., San Francisco, Calif.
'15 Schwabacher-Frey Stationery Co., 609-11 Market St., San Francisco, Calif.
'15 Ship Owners' and Merchants' Tug Boat Co., Foot of Green St., San Francisco, Calif.
'15 Sherwin-Williams Co., The, 454 Second St., San Francisco, Calif.
'15 Smith Cannery Machine Co., 2423 South First Avenue, Seattle, Wash.
'15 Standard Gas Engine Co., Dennison and King Sts., Oakland, Calif.
'15 Standard Oil Co. of California, Standard Oil Building, San Francisco, Calif.
'15 U. S. Rubber Co. of California (W. D. Rigdon, Mgr.) 50-60 Fremont St., San Francisco, Calif.
'15 U. S. Steel Products Co., Rialto Building, San Francisco, Calif.
'15 Wells Fargo National Bank of San Francisco, Montgomery and Market Sts., San Francisco, Calif.
'15 Western Fuel Co., 430 California St., San Francisco, Calif.
'15 Western Meat Co., 6th and Townsend Sts., San Francisco, Calif.
'15 White Bros., 5th and Brannon Sts., San Francisco, Calif.

## ACTIVE MEMBERS

'16 Adams, Prof. Charles C. State Museum, Univ. of the State of N. Y., Albany, N. Y.
'27 Adams, W. Carson 729 Brown-Marx Bldg., Birmingham, Ala.
'13 Adams, William C. Division of Fisheries & Game, State House, Boston, Mass.
'18, '23 Ainsworth, Seth M. Supt., Bureau of Fisheries, Saratoga, Wyoming.
'20 Albert, W. E. State Fish & Game Warden, Des Moines, Iowa.
'98 Alexander, George L. Grayling, Mich.
'25 Allsopp, Edward E. 33 East Kinney St., Newark, N. J.
'26 Alm, Dr. Gunnar Commissioner of Freshwater Fisheries, Lantbruksstyrelsen, Stockholm, Sweden.
'23 Amsler, Guy Department of Fish & Game, Little Rock, Ark.
'24 Anderson, Anders Shoshone Falls, Jerome, Idaho.
'08 Anderson, August J. Box 704, Marquette, Mich.
'14 Anderson, T. T. 4241 Folsom Avenue, St. Louis, Mo.

'24 Annin, Harry K. Spring Street, Caledonia, N. Y.
'14 Annin, Howard Caledonia, N. Y.
'78 Annin, James Caledonia, N. Y.
'26 Armstrong, Hon. Harry M. Commissioner Fish and Game, 452 Montgomery St., Jersey City, N. J.
'25 Atherton, Giles El Dorado, Kansas.
'10 Augur, W. A. 33 Fulton Street, New York City, N. Y.
'06 Avery, Carlos 2273 Woolworth Bldg., New York City, N. Y.
'28 Avey, E. S. Elma, Wash.
'01 Babcock, John P. Provincial Fisheries Department, Victoria, B. C., Canada.
'12 Babcock, William H. 140 South Dearborn St., Chicago, Ill.
'25 Bailliere, F. Lawrence 220 W. 19th St., Tulsa, Okla.
'25 Baker, Augustus L. L. Dover, N. J.
'27 Baker, Clarence M. 2 South Carroll St., Madison, Wis.
'15 Balch, Howard K. 158 West Austin Ave., Chicago, Ill.
'01 Baldwin, O. N. U. S. Bureau of Fisheries, Saratoga, Wyo.
'98 Ball, E. M. U. S. Bureau of Fisheries, Washington, D. C.
'23 Bangham, Dr. Ralph V. Wooster College, Wooster, Ohio.
'20 Barbour, F. K. Linen Thread Co., 200 Hudson St., Cor. Canal, New York City, N. Y.
'05 Barbour, Prof. Thomas Museum of Comparative Zoology, Cambridge, Mass.
'26 Barnes, J. Sanford 52 Vanderbilt Ave., New York, N. Y.
'17, '24 Barney, Raymond L. Middlebury College, Middlebury, Vt.
'19-'25 Bartlett, Mott L. Commissioner of Fisheries & Game, Concord, N. H.
'12 Bauer, A. 2500 South Dearborn St., Chicago, Ill.
,28 Beakbane, Alfred Bernard 31 Thompson Ave., Glens Falls, N. Y.
'24 Beakbane, Lionel R. F. D. 2, Gansevoort, N. Y.
'00 Beeman, Henry W. New Preston, Conn.
'28 Bell, F. Heward International Fisheries Commission, University of Washington, Seattle, Wash.
'18 Bellisle, J. A. Inspector General of Fisheries & Game, Quebec, Canada.
'80 Belmont, Perry 1618 New Hampshire Ave., Washington, D. C.
'28 Bengard, F. A. Springerville, Ariz.
'25 Bengard, John P. Valley Ranch, New Mexico.
'27 Benjamin, H. F. 61 Broadway, New York, N. Y.
'13 Berg, George Indiana Fish Commission, Indianapolis, Ind.
'27 Berry, Frank 2309 North 28th St., Tacoma, Wash.
'27 Biddle, Spencer R. F. D. No. 1, Vancouver, Wash.
'27 Birdseye, Clarence General Seafoods Corporation, Gloucester, Mass.
'24 Bitzer, Ralph Montague, Mass.
'24 Blanchard, Charles State Fish Hatchery, Unionville, Conn.
'25 Blankenship, Dr. E. L. Cassville, Mo.
'24 Bobleter, J. W. Supt., Yellowstone Hatchery, Emigrant, Mont.
'25 Bolles, Henry J. U. S. Fisheries Station, Bozeman, Montana.
'23 Bolstad, Sidney L. 4344 N. Winchester Ave., Chicago, Ill.
'14 Bolton, C. C. 1550 Hanna Bldg., Cleveland, Ohio.
'20 Bonner, Albert E. Coopersville, Mich.
'02 Booth, DeWitt C. U. S. Bureau of Fisheries, Spearfish, S. D.
'26 Borcea, Dr. Jean Univ. of Jassy, Jassy, Roumania.
'25 Borger, Samuel I. Brookhaven, Long Island, N. Y.
'28 Borges, William F. 450 Broadway, Milwaukee, Wis.

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